BEES AND Bee-keeping

VOL. II.

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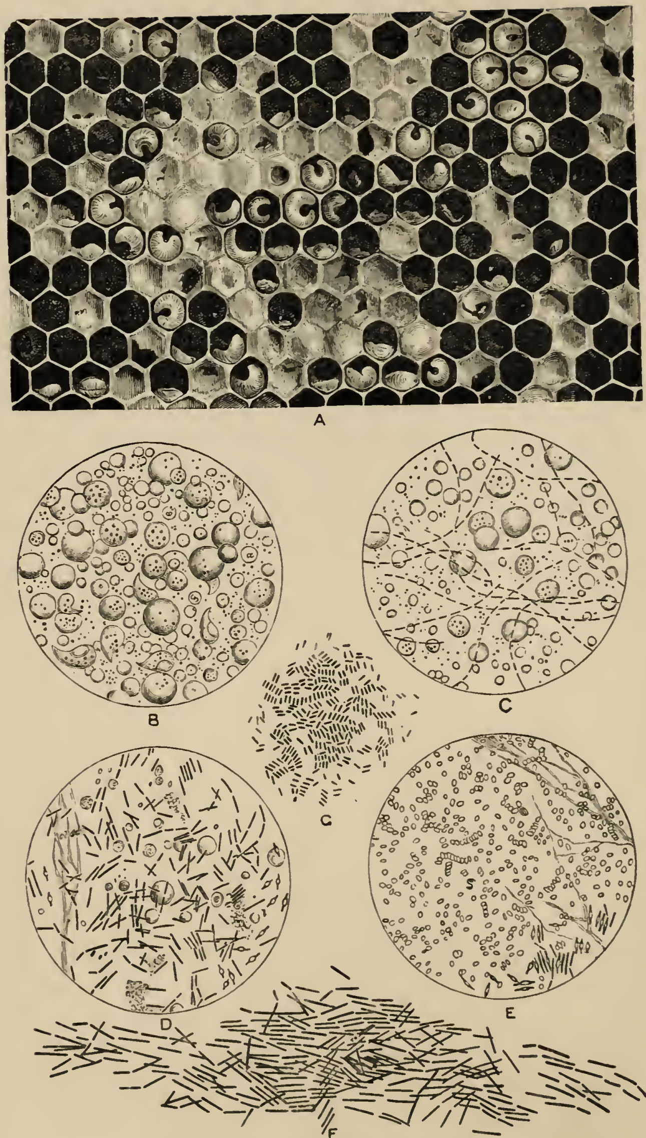
BEES AND BEE-KEEPING

SCIENTIFIC AND PRACTICAL.

Plate I.



Bacillus Diseases of Bees.

A, Comb from Hive suffering from *Bacillus alvei* (Foul Brood)—Natural Size. B, Healthy Juices (500 diameters). C, *Bacillus alvei* in Juices, Early Stage, Leptothrix Form (500 diameters). D, *Bacillus alvei* in Juices, Later Stage (500 diameters). E, *Bacillus alvei*, Spores, Latest Stage (Coffee-coloured Material) —500 diameters. F, Streak of Blood laden with *Bacillus alvei* (1000 diameters). G, Group of *Bacillus Gaytoni* (500 diameters).

BEES & BEE-KEEPING;

Scientific and Practical.

A Complete Treatise on the Anatomy, Physiology, Floral Relations, and Profitable Management of the Hive Bee.

BY

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AUTHOR OF "DIAGRAMS ON THE ANATOMY OF THE HONEY BEE;" "PRACTICAL BEE-KEEPING;" "ABDOMINAL DISTENTION IN BEES DURING WINTER;" 'HONEY AS FOOD;" "THE APPARATUS FOR DIFFERENTIATING THE SEXES IN BEES AND WASPS;" "THE RELATIONS OF INSECTS TO FLOWERING PLANTS;" "FOUL BROOD NOT MICROCOCCUS BUT BACILLUS—THE MEANS OF ITS PROPAGATION, AND THE METHOD OF ITS CURE;" ETC., ETC.

With Numerous Illustrations of the Internal and External Structure of the Bee, and its Application to Plant Fertilisation; Bee Appliances, and Methods of Operation, Diseases, &c., expressly drawn for this work by the Author.

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CONTENTS.

ERRATUM.

Page 463, line 15. *For* destroying, *read* restoring.

BEES & BEE-KEEPING.

INTRODUCTION TO VOL. II.

In entering now upon the practical aspects of apiculture, and striving to understand what the intelligence and ingenuity of man have already accomplished in converting the wondrous capabilities and instincts of the bee into an instrument for his material advantage, it is hardly possible to avoid some regrets, and the casting of a wistful glance towards the path we have long trodden together, opening up to us, as it has, so many marvels, not infrequently awakening a thrill of delight, though sometimes leaving us humbled, in making us realise that, even in what we are pleased to call the little things of the realm of Nature, we stand before an invisible Presence whose wisdom is inscrutable. But, while we reflect that art and man's device lag sadly behind in the perfection of detail animated creation

everywhere presents, and that upon the former we gaze perhaps as frequently to criticise as to admire, it is a consolation to remember that the studies through which we have passed, and the conclusions we have reached, will constantly recur, as forming part of the foundation of a truly scientific system of management; and we shall not be long in discovering that our knowledge of the bee, as such, will act as a master key in unlocking and unravelling the main difficulties of the utilitarian side of the question, proving again that knowledge is not merely power, but frequently money also. None can have read with any care the recent journalistic literature of bee-keeping without some surprise, and, possibly, perplexity, at the marked divergence of opinion amongst those whose dictum would by most be regarded as authoritative. We find, not only divergence, but direct opposition, one denouncing as a blunder what another claims as an advance. It is true that many roads may lead to one goal, and that methods having very little in common may be equally successful; while dissimilarity in purpose, purse, and taste, may induce even an antithesis of system, which may be, nevertheless, thoroughly justified. *Quot homines tot sententiæ* is not so much a charge against man's judgment as a testimony to the infinite diversity of the circumstances which limit him; but the extreme disagreement to which attention has just been called, and which the now fashionable "selected questions" have made prominent, cannot, in the Author's judgment, even in the majority of cases, be explained by any or all of these suggestions, but

points to a too common forgetfulness or ignorance of first principles and scientific fact.

The man who believes that the thaw, and not the frost, bursts the water-pipe, will act quite differently, in his endeavour to prevent catastrophe, from the one who correctly understands the case. The disagreement in method is not due to inequality of logical faculty—for here the men may be equals—but to erroneous premises, leading to a wrong deduction. Similarly, the disagreement of the "Doctors" will be found to be often traceable to ignorance of a sorely neglected branch of apiculture—the one, indeed, to which it has been the Author's special endeavour to direct attention; and since he cannot escape stating an opinion upon debatable matters, it shall be given without any mental reservation, and will be supported, to the best of his ability, by the grounds upon which it appears to him logically to rest. It will thus, at least occasionally, happen that he will have many, possibly all, of the great names against him; but, in such cases, he will not, in justice to his readers, hesitate to point out his isolation, and the more carefully to give the reasons which induce him to dare to differ from ordinarily recognised authority. This course may seem lacking in prudence, but he is encouraged in it by the remembrance of the practical unanimity with which errors, now fully exploded, have been received and propagated; showing that the voice of the majority is by no means necessarily accurate, but that, perhaps even frequently, error is with the many, and truth with the few. But it must not from this be imagined that the Author lightly

values the legacy of accumulated observation we inherit, or that he has any intention of replacing the individual experience of others, except in the spirit of the ancient and wise admonition, "Prove all things, and hold fast that which is good." He thus trusts that he may be saved everywhere from the teaching of error; but if, unhappily, not, he can only say, time is with the truth, and may it quickly prevail!

A mere fragment of space will be devoted to the history of apiculture (of which enough and to spare has been written in most guide-books), all our attention being needed for the subject as it now presents itself, since our difficulty consists in saying all that seems desirable within the limits of a readable book. The ancient workers did indeed well, and should spur on our efforts, for freely we have received, and it is for us to freely give: but their methods of investigation were crude, and their hives clumsy, while the microscopy and chemistry of their day were valueless; and, unfortunately, their shortcomings in methods of investigation were made up, in many cases, by a fertility of imagination which has given currency to fancies from which we have not even yet shaken ourselves clear. In recent times progress has been rapid, for practical apiculture is an art which has, during the last forty years, not only undergone a complete revolution, but has attained a development and multiplicity of detail which would have bewildered our immediate predecessors. It is often said that improvement leads to simplification; but this is only in a certain sense true. The stage coach is not more simple

than the springless bullock-truck, nor is the locomotive more simple than the stage, but surpassingly more complex; for improvement consists in securing a certain advantage by readier methods, or by gaining a greater advantage by some, possibly more intricate, plan. So in apiculture, the relatively splendid results now attainable demand immensely more care, attention, foresight, and knowledge, than the bygone "let-alone system"; and, again, as we learn to secure greater harvests from a single stock, civilisation and competition demand and necessitate some greater refinement in the method of marketing the crop; so that progress has not shown the way to wealth to the idle, but has, rather, increased the labour of the bee-keeper, though it has undoubtedly sweetened that labour by making it more intelligent. The keeping of bees has about it a fascination peculiarly its own, and so many have, *con amore,* joined the apiarian ranks in recent years, that the output, often exceeding an average of 60lb. per hive, has grown more rapidly than the demand; hence, prices have decreased. All methods of saving both labour and capital must, therefore, be carefully studied by those who are apiarians by profession; while the *dilettante* bee-keeper may satisfy his tastes, since to him pleasure, and not profit, is the aim. To satisfy the needs of both, miscellaneous appliances, which are from any point of view genuinely serviceable, will be introduced in our subsequent chapters; but, of course, the intelligent reader will understand that he is in no way recommended to possess himself of anything until he is first convinced that his particular requirement is thereby

met. The illustrations are, in all desirable cases, actually working drawings, made to scale, so that the amateur carpenter may increase his gratification by becoming his own hive and appliance manufacturer, introducing any modification which his inventiveness may suggest; but, in fairness to the professional, it should be here stated, that hives are now turned out at prices little, if at all, in advance of the cost of materials to those who purchase in small quantities.

It is, perhaps, hardly possible to arrange the chapters in a manner that shall be strictly logical, or so that the treatment of each subject shall in no case presuppose a knowledge of matters to be subsequently considered; but this difficulty is of less than usual moment, since readers will commonly be already bee-keepers, and probably familiar with one or more of the smaller treatises.

Let us now commence our journey together. The Author, while acting as guide, claims no infallibility, but simply a consciousness that he has no interest to serve but truth, which he trusts will at all times save him from any imputation of selfish bias, however much his judgment may be held to be defective. He desires to eschew every "fad," to steer clear of every prejudice, and to avoid all suspicion of partiality; and should the reader meet positions contrary to those he cherishes, he is asked, before giving the verdict in his own favour, to carefully consider the stated principles upon which the Author bases his judgment; and in all cases let us be at one in the desire that light may spread, to the end that the bee-keeper may be ennobled and apiculture advanced.

CHAPTER I.

BEES UNDER PROPER CONTROL.

Stings—Bee Dress: Gloves, Veil, Mask—Terrifying Bees—Langstroth's Law (?) Disproved by Dissection of Bees Volunteering an Attack—Heddon's Criticism—Smoke and Smokers—Clark's Cold Draught Examined—Carbolic Acid as a Quieter—Mixture used by Rev. G. Rayner—Spraying with Carbolic Acid—Mr. Howard's Plan—A Bee-keeper's Atomiser—The Webster Fumigator—Mr. Sproule's Method of Using Creasote—Cyprians: Their Temper; How to Treat—Anointing to Prevent Stings—Methyl Salicylate—Sting Palpus—Extracting Stings—Cures.

DREAD of the marvellously perfect and relatively formidable instrument of attack and defence the bee possesses has doubtless deterred multitudes from the pursuit of apiculture as a delightful and health-giving recreation, while possibly it has not been without its effect upon some of those whose tastes might otherwise have led them into the adoption of bee-keeping as a means of support. A correct estimate of the risks to be run, as a set-off against the enjoyment and profits to be realised, ought to be made at the outset; for the character of hive we may adopt, and

the system we may pursue, will depend in no inconsiderable degree upon the extent to which we realise that the greatest possible liberties may with impunity be taken with this insect, notwithstanding its ability to inflict pain. To follow the footsteps of our forefathers, hiving swarms in skeps, and letting them stand until autumn to gather as best they can, and then, under cover of darkness, committing the industrious creatures to suffocation over the fumes of burning sulphur, requires but little of that courage upon which, to the uninitiated, the modern school, with its hives that turn inside out, would appear to draw rather heavily. Light is, however, being diffused, and the manipulations given in connection with our numerous county associations, at agricultural, flower, and other shows, have at least made clear that he who knows the art has bees completely at his bidding. Let us, then, describe how the learner may become master of the situation; for his favourites will be more disposed to resent his interference at first than after he has acquired the method of deftly performing the necessary operations of a modern apiary. The warrior who has donned an impenetrable armour may well be fearless; and so with the novice—the more complete the protection, the greater the calmness under unexpected difficulty—so that, if he would avoid even risk, he may dress thus: Gloves of india-rubber, like those used by photographers, and which are lined, for those consisting of rubber exclusively, although less clumsy, are too troublesome to get on and off. Yet this difficulty may be lessened by the use of French-chalk dust, commonly called "boot

powder." Indiarubber is *perfectly* sting-proof, but impervious to perspiration, and so most unpleasant in hot weather. A woollen glove, covered by a cotton one, and worn wet, practically secures the hand against all assaults, while scarcely interfering with the comfort of the operator. To the gloves should be added, by stitching on the outside, gauntlets of calico, about 5in. or 6in. wide, and carrying an elastic band, which, passing over the coat cuff, absolutely saves the upper limbs from danger. In chilly weather especially, bees are likely to fall to the ground, and crawl up the legs of the operator, and administer stings under pressure; so that a string round the ankle, over the trousers, may not be without its advantages. Those ladies who undertake general manipulations amongst bees would do well, if stings affect them much, to wear a divided skirt, and protect the ankles.

Gloves are soon thrown up as confidence is gained; but even the expert must often protect his face. For this purpose, make a veil in the form of a bottomless bag, by joining the ends of $1\frac{1}{4}$yds. of leno; make a hem at the selvage, and run in an elastic about 15in. or 16in. long when slack, so that it may clip round the hat, as at A, Fig. 1. If it be passed under the collar, and the coat buttoned over it, while any excess is stowed in the opening of the waistcoat, it will enable us to laugh at the assaults of the enemy, provided the hat brim be only broad enough. These veils are occasionally made of white material, but the part standing before the face should always be black, or the threads of the net will reflect light, and themselves be seen, so as to materially impede our view

of the creatures with which we have to deal. Veils of wire cloth are obtainable of all hive-dealers ; these are transparent, but are cumbrous and awkward, while the idea that they are safer, because their stiffness holds them at a distance from the face, is quite illusory. They are sometimes moulded into masks, with an opening for the pipe, and a draw-door to permit of expectoration ; but, as a non-smoker, I have no need of, and have had no experience with, such con-

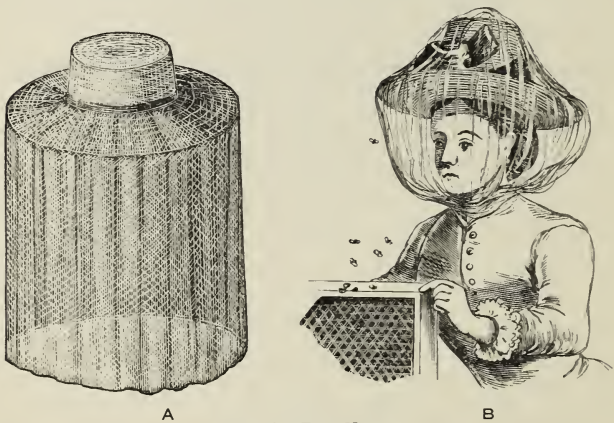

FIG. 1.—BEE VEILS.
A, Bee Veil as placed on Hat. B, Silk Net Bee Veil as worn by Lady Operator.

veniences, beyond knowing that these wire masks are almost always discarded after a time for the more simple, portable, and withal convenient, contrivance. I prefer immensely, and generally carry in my pocket, a bee veil made of fine black *silk* net, which is not, in the end, expensive, as it is remarkably durable, and occupies very little room, since it can easily be hidden in the closed hand ;

while it is cool in wear, and weighs a bare ½oz. It admits also a much better view through it than leno, on which account it is strongly to be recommended to those desirous of studying the economy of the hive. The face-protector for ladies is preferably sewn up above the hat, as at B, Fig. 1, any ornaments upon which would prevent the elastic just described from making a bee-proof joint. A little practice will generally cause all protective dressing to be discarded but the veil, and even this, when stocks are gathering honey freely, is unnecessary. But our safety is as fully secured by putting the bee upon its good behaviour as by defending ourselves from the attack ; and our success here depends upon two plans : *either terrifying the bee into submission*—for which purpose smoke is generally used—or *gaining its confidence by gentleness.* It would be unpardonable here to omit that, since Langstroth wrote his invaluable treatise, by almost universal consent the supposed sheet anchor has been inducing the bees to gorge, by which it has been a thousand times stated they become imperturbably amiable, and as harmless as flies, and even, according to some, unable, as well as unwilling, to use their stings. But let Langstroth* speak for himself : "One of the peculiarities which constitute the foundation of my system of management, and, indeed, the possibility of domesticating at all so irascible an insect, has never, to my knowledge, been clearly stated as a great and controlling principle. It may be thus expressed : *A honey bee, when filled*

* Langstroth's "Hive and Honey Bee," page 25.

with honey, never volunteers an attack, but acts solely on the defensive. This law of the honeyed tribe is so universal, that a stone might as soon be expected to rise into the air without any propelling power as a bee, well filled with honey, to offer a sting unless crushed or injured by some direct assault." If this be accurate, we have a means of making bees, however vicious, perfectly harmless; but most assuredly it is very far from correct. I have been fiercely stung by bees darting from a hanging swarm to which I have offered no kind of violence,* and frequent dissections of bees which have volunteered an attack have shown that these are very generally full of honey, while empty ones are the more submissive. Every experienced bee-keeper must know, too, that rich stocks are more belligerent than poor ones, while those in actual want resent nothing. The truth seems to lie here: Bees, when terror-struck, rush to fill themselves at their stores, and are then harmless, not because they are filled, but because terror-struck. Their gorging is the *result* of their submission, not the converse. It is really remarkable how constantly effect has been taken for cause, but I am pleased to find that Mr. Heddon combats the position of Langstroth, whose error may often lead to loss of time, and loss of command also. Mr. Heddon† says: "We have been told that the reason the application of smoke puts bees in a friendly attitude is because it frightens them, which causes them to fill themselves with honey, and when so filled they cannot, without disgorging

* "Practical Bee-keeping," page 30.

† "Success in Bee-culture," page 18. James Heddon.

the same, assume an attitude in which they can use their stings. While this teaching may be correct* in part, I think that the effect of smoke is to frighten out of them all idea of battle. It seems to instantly impress them with the utter uselessness of opposing 'an enemy with a breath like that.'"

Smoke, then, although not without a rival, to be

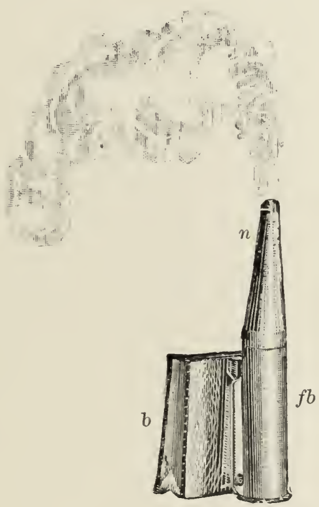

FIG. 2.—BINGHAM SMOKER.
b, Bellows; *fb*, Fire-box; *n*, Nozzle.

hereafter introduced, is the bee-keeper's talisman, and, with this properly applied, almost all races of hive bees may be completely and immediately tamed, or rather terrified, into submission. If in the summer time a skep be lifted from its stand, even with the greatest care, many of the brave little inhabitants will

* This teaching has not a shadow of a shade of truth in it.

sally forth to repel the disturber; but if a few puffs from a pipe or from smouldering rag had first been blown into it, the bees would have retreated between the combs, where they might have been easily kept by a further dose after the skep had been lifted and turned up for examination. The habitual consumer of tobacco, who owns but a few hives, may perhaps shift with his pipe, from the stem of which he may pour a terrifying stream by grasping the bowl between his little finger and palm, and with the remainder of his hand forming a tube, through which he blows; but to those to whom "the weed" is no solace a "smoker" is indispensable. All the different forms of these are practically reducible to two—the Bingham and the Clark—although our English makers have given various names to them after adding special hand-guards to prevent burning, or making some alteration which does not touch general principles. The Bingham (Fig. 2) is mostly used, and is my preference, for reasons presently given.

Both smokers, which are not very different, may be well understood by Fig. 3, representing them in section, and a knowlege of their construction is, in practice, necessary, as it enables the owner to see the cause of, and remedy any hitch in, their performance.

In the Bingham, the bellows boards are kept apart by a spiral spring (*sp*), while the air is admitted by the valve (*v*). When the bellows are collapsed by thumb and fingers, the air is driven forcibly out through the blast-pipe (*bp*). The current enters the lower end of the fire-box (which is pierced by a hole somewhat larger than the diameter of the blast-pipe, and

which stands opposite the latter), and now passes through the grating (*g*) and the smouldering fuel, and escapes by the nozzle. It has been urged that the smoke so ejected is objectionably hot, and hence the Clark "Cold Draught" (B). Here the bellows boards are kept asunder by an external spring (*sp*). As the bellows are flattened by the hand, the air escapes

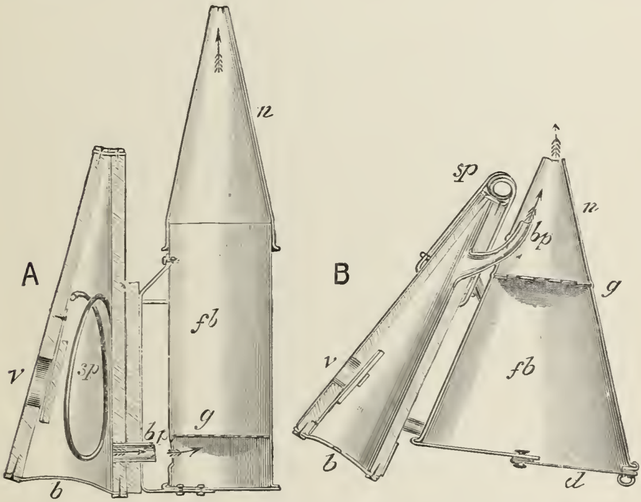

FIG. 3.—A, BINGHAM SMOKER. B, CLARK'S COLD DRAUGHT SMOKER (Sectional View, one-fifth actual size).

b, Bellows; *v*, Valve; *sp*, Spring; *fb*, Fire-box; *d*, Door to Fire-box; *g*, Grating; *n*, Nozzle; *bp*, Blast-pipe.

by the blast-pipe (*bp*), not to pass through the fuel, but to escape at once by the nozzle. It is, however, true that every air current by liquid friction draws other quantities of air into its wake, and so the smoke discharged from the fuel, and filling the nozzle, is sent forward with the blast. It is con-

tended that this mixed blast is cold. Testing this smoker by a delicate thermometer, the bulb of which was placed in the smoke about 1in. from the nozzle mouth, 230deg. was almost immediately registered; while a Bingham, burning with about the same vigour, gave only a few degrees higher. The reason for this is clear. The air from the bellows of the Clark drives forward a relatively large amount of smoke-laden, heated air from the fire-box, and so only partially reduces its temperature; but in the same degree it diminishes the amount of smoke it carries. As the stream leaves the nozzle, it mixes with other quantities of cold air, and so quickly loses its high temperature; but the Bingham does this also. Comparing the two, we find the Bingham stream hotter than that of the Clark at the nozzle, but more densely laden with smoke; while at the distance from the nozzle of the former at which its temperature is lowered to that delivered by the so-called "Cold Draught," the density of the smoke, other things being equal, has become the same. The Clark smoker, therefore, gains only this very doubtful advantage, that it may be held slightly nearer to the bees, and to achieve this it introduces two grave practical defects. First, if the fire-box were air-tight at its base no air could be drawn through the fuel for delivery at the nozzle, and so large leakage is necessary around the door (*d*), or else the door must be left partly open. This permits suffocating and blinding streams of smoke to issue, to the great annoyance of the operator. Secondly, tarry matters, always produced whatever kind of fuel is used, by

degrees get into and clog the blast-pipe (*bp*), which, on account of its form and position, is difficult to clean. It is true that the nozzle (*n*) and the grating (*g*) in the Bingham occasionally get somewhat choked; but, when this occurs, they are cleared with great facility.

The question, "Which is the best smoker?" is often asked, and for this reason I have fully stated my objection to an appliance which stands in high favour with many; and without doubt, the Bingham and the Clark are both exceedingly effective; for, if the Bingham only have a fire-tube wide enough,* both may be made to burn almost anything—peat, rotten wood, chips, wooden laths, are all excellent. I generally use brown paper, which is with us a waste product. Some of this, roughly torn, rolled up, packed pretty closely into the fire-box, and lighted (as it may be instantly by a match) either top or bottom, will smoulder for hours. The fuel is introduced in the Clark at the door (*d*), and into the Bingham by the removal of the coned nozzle (*n*). If the smokers are stood as in Fig. 4, they burn freely, because in the Clark the leak at the door (*d*) supplies sufficient air, while in the Bingham the blast-pipe not entering the fire-box, but acting like a steam injector, gives room for the admission of a current. This excellent arrangement in the Bingham also saves the blast-pipe from clogging with the tarry residues. To reduce the rate of combustion, stand the smoker on the bellows bottom; and to extinguish, plug the nozzle.

The manner of using the smoker will be hereafter

* No fire-tube smaller than $2\frac{1}{2}$in. in diameter can be recommended, except for very small apiaries.

explained; suffice it now to say, that usually a strong puff or two at once brings into subjection the largest and most fiery colony. But it must not be understood that smoke is alone useful as inspiring fear. It may be what the whip is to the horse, but often it acts as the rein, and directs the bee to follow the course we desire. A hive is opened, and the insects appear in numbers where they would be crushed were we to close again. But our smoker instantly removes the difficulty, since the trespassers accept its notice to quit in a twinkling; and, should they lurk in a somewhat inaccesible corner we might desire cleared, a sharp squeeze of the bellows, even at a distance of 18in. or more, will immediately cause them to take their departure, whilst with flapping of wings they sound the retreat. Some distinguished apiarians use carbolic acid (the odour of which is most hateful to bees) in the cases in which the majority employ smoke. To the Rev. G. Rayner, I believe, falls the honour of originating this method, and making it a practical success, while "Lanarkshire Bee-keeper" and Messrs. Raitt and Howard give to it applications of considerable value, to be noticed under their appropriate chapters. It is now followed by a constantly-increasing number, and in manners which seem to indicate that it will ere long displace smoke in certain manipulations. The originator has favoured me with the following summary, which, although it anticipates some matters, I prefer to give in *extenso*:

"I have used carbolic acid as a bee-quieter in preference to smoke for upwards of twenty years, and consider it more easy of application, equally effective,

and less disturbing to the bees, while to its powerful antiseptic property I attribute chiefly the immunity I have enjoyed in my apiary, for a period of forty years, from the much-dreaded disease of foul brood. Much care is required in the use of it, since it is a most powerful acid, blisters the skin, and is highly poisonous. As a bee-quieter I use it, in solution only, in the following proportions :—

1½oz. Calvert's No. 5 carbolic acid.
1½oz. glycerine.
1 quart of warm water.

The acid and glycerine to be well mixed before adding the water, and the bottle to be well shaken before using.

"The application is very simple. A goose quill or a small brush, moistened with the solution, is passed over the alighting-board, and around and within the entrance. The quilt is then raised slightly and gently on one side of the hive, and the brush, replenished with solution, is passed over the frames as far as the centre of the hive, when the quilt is allowed to fall into its place. The other side of the hive is treated similarly, and the manipulation may then commence on either side, the brush being kept in readiness for use when required, a few passes over the tops of the frames occasionally being all that is required to keep the bees quiet. Bees thus treated are less inclined to form clusters, and to roll off the combs, than when under the influence of smoke. Another method of application is to steep a piece of thin calico in the solution, and, after wringing it, to spread it over the frames of the hive, when every bee will disappear. Cases of sections, also, may be thus cleared of bees

and removed from the hive while the bees are at full work."

My experience with carbolic acid leads me to regard it as quite invaluable in certain operations, but I could not subdue an irritable stock so promptly by the means Mr. Rayner gives as with smoke. Painting over the frames occupies considerable time, and any but an expert would be likely to give the bees first chance. The visibility of the smoke is an advantage to the learner, and he can drive a stream some distance before him, while with a feather he must come to close quarters. With a powerful spray-producer, such as used by gardeners, and holding half-a-pint of water, with about $\frac{1}{50}$th part Calvert's No. 5 carbolic acid, I have managed many stocks, since my experiments on the cure of foul brood (see "Diseases"), with most satisfactory results. To Mr. Howard, however, must be ascribed the credit of calling the attention of bee-keepers to the value of the carbolic spray. He adds about 10 per cent. of good liquid carbolic acid to warm water, and, as the quilt is being withdrawn, applies this in fine splashes from a flat brush, or, preferably, by an atomiser. The bees instantly retreat in dismay; and, should they appear again to apparently calculate what chance they have with the enemy, a second fine shower completely cows them. This treatment is in itself antiseptic, and therefore useful where disease threatens, as Mr. Rayner wisely hints, and checks robbing (see "Robbing") in a most helpful manner. The atomisers of the drawing-room and operating-theatre are too delicate for apiary work, and if the makers would

only give us one like to that I have rigged up for my own use, it would be an advantage. It consists of an ordinary Bingham bellows, with its blast connected to the spraying bottle by an indiarubber tube. On the top board of the bellows is fixed a zinc tube-like case, into which the bottle fits, while the zinc bottom of the case is continued over the front of the bellows, to prevent them being injured by drip. The zinc case is so deep that it extends above the bottle, which could not be broken if the arrangement were dropped. Slots are made before and behind, to give exit and entrance to the spraying nose and the indiarubber tube, the former being protected from dirt by an external pipe 1in. long and $\frac{3}{4}$in. in diameter.

Mr. Webster makes an apparatus much like a Bingham smoker in form, holding in the body a sponge, which he at first purposed soaking with carbolic acid, but now employs, at my suggestion,* crude creasote. Indeed, where common carbolic acid is used to terrify bees, the main effect is produced, not by the carbolic acid itself, but by the impurities with which it is associated, of these, the cresols being the most important. Mr. Howard, instead of introducing a special piece of apparatus, fits a case into the fire-box of the Bingham, thus making what he has denominated the "Raitt fumigator." This case carries wadding saturated with carbolic acid, the vapour of which is driven forwards, as smoke would be. It appears to me, however, that no additional machinery of any kind is required, and that strips of

* Mr. Webster, to his honour be it said, most openly and handsomely acknowledged my little help in the *British Bee Journal.*

creased brown, alternated with blotting-paper, rolled up until the diameter of the fire-box is reached, tied with string, and then soaked with the nauseating material, and placed in the ordinary Bingham, will act as well as a specially-made fumigator ; while, if *corrugated* brown paper be substituted for the ordinary, the passing air is driven through a multitude of small tubes, and is even more fully charged with vapour than it would be in travelling through and around a sponge. With very savage stocks, Mr. Sproule suggests that the creasote, to the amount of a few drops, should be rapidly vapourised by being added to the *burning* material in the usual smoker. When so employed, no colony can stand against it. He relates that one of his, that seemed utterly untamable, gave in at once; and Mr. Simmins by this method immediately vanquished some Syrians—of which more anon—which had been the *bête noir* of his whole apiary.

In thus pointing out the best means of making bees succumb to our wishes, variations in race must not be overlooked. In former days, I had one or two sore battles with Cyprians, which, I have little doubt, might have been altogether avoided had I then known the special peculiarities of these most handsome bees. Their courage is boundless ; but their calmness is as marked, and no bees are less likely to interfere with a visitor to the apiary, and none can do more work with so little external fuss ; but they have immense "decision of character," and cannot be conquered, after their antagonism is fully aroused, until their ranks are decimated and all are

weakened, to say nothing of the pangs of the operator, and the uproar in the apiary. Although Cyprians cannot be subjugated by smoke, which maddens rather than terrifies them, certain strains of them at least, if suitably treated, are even more amenable to the manipulator than ordinary Ligurians. I am not unconscious of the strong condemnation they have received from such an acute and reliable observer as Mr. Raitt, and many others, whose opinions cannot be lightly put aside; but I "speak that I do know, and testify that I have seen," in adding that, although now and again a vicious Cyprian stock is met, yet that a bad name could not possibly be given to those in my possession, as well as to those I have had an opportunity of handling in the apiaries of others. Nor can I doubt that in some quarters bad reports of Cyprians have come from owners who have failed through not understanding how to approach them. It is said with truth, that men in their treatment of us are often like looking-glasses—reflecting our mood, frowning on us if we frown on them, but receiving us with hearty goodwill if we give evidence of confidence and respect. This is pre-eminently true of Cyprian bees. Gentle measures find them gentle. With as little disturbance as possible lift the quilt from two or three frames, and if the bees then appear fussy, wait a few seconds, on no account using smoke. The insects will seem to realise that the intrusion is not that of an enemy, and will quiet down, when we may proceed to totally uncover and examine. As the frames are now lifted, and the light streams on to the backs of these little beauties,

their unusual stillness is very noticeable. To please friends rather naturalists than bee-keepers, and who have wished to see "the Cypriots," I have frequently fetched a frame, carrying bees and queen from a hive about 200ft. away, and, having made my exhibition behind glass, have returned all to the *status quo ante* without a single bee flying, or indicating any disturbance. When recently visiting Rottingdean, *carte blanche* was given me with regard to the apiary, and in indifferent weather I fully examined and carefully tested the temper of the Cyprians, taking stock after stock without veil or any protection, and in no case received even a threat of a sting. Cyprians have faults in our climate, as well as excellencies, quite outside the question of temper; but their surpassing loveliness of form and colour would induce some to keep them, especially if their disposition could be reckoned upon, and to this end irritable colonies, whenever discovered, should be re-queened; but our point here is—*with Cyprians use no smoke*, and with them, as with all bees, avoid all quick, darting movements. So handle the combs that they are not jarred, and be especially cautious not to strike or kick the hive. Make no needless noises, and do not allow the breath to play upon the bees; and should one dart out with threatening mien, strive to remain unmoved, when escape is extremely probable, while a hand in retreat is almost certain to retire wounded. Should our gentle wooing be uncannily received, it is best with Cyprians to give up for the time, or else conquer by the carbolic spray or smoker with creasote added. These, especially the

former, may, indeed, be used from the first, but for myself I would prefer, with Cyprians, to regard these methods only as alternative.

But another style of defence remains to be noticed, and which is certainly well worthy of the attention of the learner whose confidence is only in the making. At the first bee show at the Crystal Palace (1874), well do I remember the comical expression that stole over the countenances of more than one who asked to be informed in confidence what substance was rubbed upon the skin to prevent the bees stinging, for then the onlookers could not imagine that the mastery of the manipulators was other than some trick upon trained bees, or the result of some secret anointing. The idea that then caused merriment as a ludicrous fancy has been actually tested, and Mr. R. Franks, writing to the *British Bee Journal*, August 1st, 1885, says that by washing the hands with vinegar, and allowing it to dry on, those handling bees will escape being stung. This plan really has its value, as has also rubbing the hands with common disinfecting powder; but both of these applications do not act upon the skin as Pears' soap is advertised to do. An oily body, however, which, judging from my own experience, would not spoil the whitest hand, and known to the chemist as methyl salicylate, is infinitely more effective, and, after applying a few drops of it, I have been quite unable to get my own bees to sting me. But, judging that home stocks might not put this restrainer of naughty bees to a severe test, since I generally prepare any queen breeding savages for a *post-mortem*, I determined to try my fortunes upon

the before-mentioned "awful example" at the Rottingdean apiary. This fearfully vicious stock covered twenty standard frames, in two storeys. The afternoon of the 3rd September was cloudy and misty, with strong wind and high temperature. The bees were flying, but gathering was all but over—the conditions just those to breed ill-temper: plenty of work, but terribly small wages. Mr. Simmins and myself put four drops each of methyl salicylate into our palms, and then, "washing our hands with invisible soap, in imperceptible water," we proceeded to open the hive. The bees came at us like pellets from a pop-gun, but no stings followed; and, strangely, they constantly ran over our fingers, not exhibiting any dislike to the somewhat aromatic body coating them. We darted our hands over the disquieted insects, and I stretched out my fingers upon the top of the frames, some of which were now lifted out and examined, but they only struck us in their headlong fury. We then kicked the hive, making the bees boil up, apparently resolved to do or die, perhaps both. But Mr. Simmins escaped unscathed, while I received one sting in the knuckle. Oh! that I had been greased all over, for several got up my sleeves and took savage satisfaction. The insufficiency of mere defensive measures now became evident. We had opened the hive, but to close it was impossible, since its upper part was hidden from view by our "enemies." A thin hive quilt was placed quietly over them, and the top stood on cornerways, but some hours after numbers were outside waiting for us. The one sting in the knuckle notwithstanding, the experiment was conclusive that methyl

salicylate, or oil of winter green, gives practical immunity from stings, and as such would be hailed by some with delight, while to many more it would at least have the transient value of inspiring confidence in the abandonment of gloves. It can easily be washed from the hands, and may be purchased pure at about one shilling an ounce; but it is liable to be terribly adulterated and weakened. I have tried a great variety of substances with varying success, such as camphorated oil, cedar oil, creasote, glycerine and vaseline made into an emulsion; but the innocence, ready removal, and persistency of the odour of methyl salicylate, leaves it without a rival.

A most interesting question now arises, the key to which is given in Vol. I., page 191—Why does the bee not sting when she strikes with that intention? Because she examines the spot to which the sting is to be applied with beautiful feeling organs—the palpi (*p*, *p*, A, Plate VI., Vol. I.). At the very extremity of each of these is a delicately-haired, bulbous form, which is nervous in character, while several strongly-bulbed hairs, clearly tactile in function, are arranged immediately above it. The supposition that there is not time for the bee to determine whether she will sting or no, as "it is done in a flash," arises from our judging of her movements by our own. Large creatures are necessarily slow; but be it remembered that she can flap her wings more than 400 times per second, and that each flap involves the extension and contraction, through a nerve impulse, of the muscles employed in the wing movements, and we shall see at once that the "no

time" difficulty is removed. If a sting be received, extract immediately, for reasons given under "Sting Structure" (Vol. I.), but do not grasp the organ by the thumb and finger, as this will only force out additional quantities of the virus from the poison bag, which is almost always left behind. Pull the sting out, if possible, by the nail, running over it in the direction opposite to that by which it entered. The cures (?) for stings are legion. The poison is acid (formic being its main constituent), as may be seen by the litmus test, and so it has been argued that alkalis—ammonia, soda, &c.—should be used as neutralisers; but experience does not corroborate the theory, which is simply chemical where it should be physiological. *Arnica montana* and *Ledum palustre* appear to help many, but I have known cases in which they have been positively injurious. The system, according to a law well known to physiologists, will become habited to the poison, and so stings are usually less and less painful; but cases are well known of old hands, who have stood stinging without after-consequences, suddenly suffering severely.

This matter has been thus fully treated that the beginner may have at his will all that our present knowledge is able to provide; so that, should he find a sting a serious matter, he may have his panoply at command; but a little experience will enable almost all to so manage that every kind of operation may be performed, with the protection the veil affords, with only a sting now and again as an occasional mischance.

CHAPTER II.

HIVES FOR BEES.

Bees the Friend of Man—Man the Friend of Bees —The First Essential of a True Hive—Bees Building in Bush—Strange Swarming Places—Use of Protecting Cover—The Arrangement of the Swarm — Theoretically Globular — Disposition of Combs—Heat-giving Layer—Bees First Hive-makers — Apis Dorsata — Hive Elasticity — Small Swarms Choose Side of Hive — Hive Shape — Movable Side—Simple and Complex Hives.

We closed our last volume by endeavouring to sum up the value of the bee to the human race, her honey, although toothsome, yet forming but a minor fraction in the total of her benefits, for "seeds, flowers, and fruits, follow in her train." Truly, then, notwithstanding an occasional exhibition of naughty little ways, as we think them, she is the friend of man; and man himself, although sometimes, in ignorance of his own interest, cruel to the little creature to which he owes so much, is, after all, a friend to the bee in providing a dwelling, which wondrously increases her prosperity, as, indeed, it should, since the interests of both are bound up together. The

bee-keeper needs a hive for *his* convenience, but the first essential of a bee's true home is the comfort and well-being of the little inhabitant; therefore, let us now consider hives for bees. In 1874, the Hon. and Rev. H. Bligh presented me with a portion of a bush in which an escaped swarm had built a considerable quantity of comb, had stored honey, and raised brood for a sufficient time to have a second batch of drones considerably advanced; but adverse circumstances had greatly overmatched the *al fresco* colony, and after a brave stand they had succumbed,

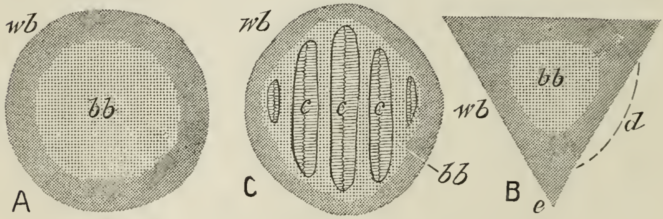

FIG. 4.—HYPOTHETICAL ARRANGEMENT OF SWARMS.
A and B, Cross Sections of Cluster—*bb*, Building Bees; *wb*, Warming Bees.
C, Cross Section after Combs are built—*c*, Combs; other letters as before.

as bees in this climate so placed must. That external protection is essential, and that the instinct of the bee leads it always to seek it, is certain; and now, as in the primeval forest, the hollow tree constantly furnishes for it a domicile while, failing this, it will shift in almost any cavity, and under my observation have fallen many odd choices, amongst which figure a wooden pump, giving entrance by the spout, a hollow wall, beneath the floor of a summer house, under the roof of a church, a recess in Dover Cliff, a disused chimney, and a pillar letter-box, from

which a Civil Servant, bearing G.P.O. on his collar, in defiance of general orders, requested me, with many apologies, to kindly make the collection.

We shall gain much every way by studying the reason an external cover augments the results of bee labours, and assists in the propagation of the species. Let us suppose an absconding swarm to remain unobserved in a bush; the bees gather into a compact mass, those on the outside (*wb*, A, Fig. 4) clinging closely together, and protecting those (*bb*) within, where a high temperature must be maintained if wax is to be secreted (Vol. I., page 160). They would, theoretically, assume a form circular in cross section; for, imagine the disposition of the sustaining twigs to be such that a triangular outline (B) is induced, then the bees at the angular point *e* would straggle away to *d* at the centre of the side, to be more closely identified with the rest, and this would continue until the triangle had become a circle. We see the same thing in a street crowd, which naturally takes the round form, because those standing at any angle change to a spot where a better view of the centre may be obtained. The instinct just referred to—the clinging of the bees to each other, and gravity stretching them downwards—disposes them in the form of an inverted cone, closed on all sides by serried, clinging ranks, except at the point where a small opening is left for the exit and entrance of the interior insects. Cutting the cone now horizontally, we should find the bees within somewhat loose, and disposed in festoons as a preparative for comb-building; while the outside bees, forming a protecting

wall, would have no other function than to husband the heat of the wax-workers. After a few days, a similarly made section would give us the disposition of parts seen at C, Fig. 4. Centrally, we have the largest and first started comb, and on the right and left others less developed, so that the united outline is approximately spherical, or rather elliptical; for, the side of the comb being a better defence than its edge, the diameter of the body of bees tends to increase most in the direction of the combs' length. Upon

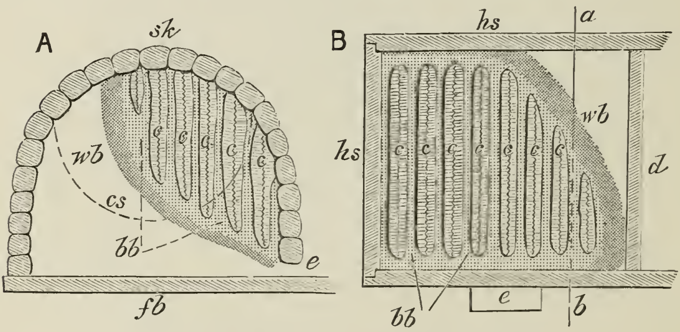

FIG. 5.—SWARMS PARTIALLY OCCUPYING HIVES.

A—*sk*, Skep; *fb*, Floor Board; *e*, Entrance; *c*, Combs; *wb*, Warming Bees; *bb*, Building Bees; *cs*, Line for Central Station. B—*hs*, Hive Side; *d*, Diaphragm, or Dummy; *e*, Entrance; *c*, Combs; *wb*, Warming Bees; *bb*, Building Bees.

and around the combs are the builders and nurses, while an agglomeration of bees furnishes the envelope, of from 1in. to $1\frac{1}{2}$in. in thickness. This peripheral mass takes no direct part in the work going on within, except, as already said, in making it possible there to preserve a temperature of 95deg., which is the most favourable for the secretion of wax and the raising of brood. This envelope, or crust, would increase or decrease in thickness according to atmospheric changes.

On our hottest days, since its services would be unnecessary, it would break up altogether; but with the sinking of the thermometer, as the sun approaches the horizon, the bees would hasten to re-form the external mantle, its thickness growing most rapidly on the side of the cone most exposed to the chilling influences of any air-current. The working population is thus in a hive the sides of which are formed of living bees, who would appear from this to be the most ancient hive-makers. This observation teaches us at once the primal advantage of the covering, whatever be its form, in which our bees are kept. It is, as Fig. 5 will make clear, to diminish, or even to make needless, the inactive peripheral crust, by substituting for it walls such bad heat conductors that, by their help, the workers alone may keep up the necessary temperature for wax-working and brood-raising; so that the greatest number, or even all, of the population may be disposable for active service. In temperate latitudes, bees can sustain themselves year after year in clefts of rocks, or hollow trees, but in the open never, as the former situations alone liberate the main body for remunerative labour. The advantage of some cover is even observable in *hot* climates. The *Apis dorsata* of India commonly builds beneath the branches of trees, and here the comb is always single, with dense clusters of bees on each side of it; but should this species begin to build in a rock crevice, the side protection releases so many for work that the combs are duplicated, and the colony becomes unusually numerous. Those hives, then—other things being equal—will give the best results which most

completely annihilate the exposed surfaces of the swarm, which would require such large contingents of bees as mere heat-formers if left unprotected.

Since swarms vary much in weight and numbers, and the same swarm occupies more space as its combs increase, we have brought before us the need of elasticity in the hive, a feature of great importance, which has been overlooked until quite recent years. By way of illustration, let A, Fig. 5, represent in section an ordinary straw skep. If a colony large enough to fill it as they hang in festoons be placed within, the protection is so complete that the bee-envelope is not required, and during the warm part of the day multitudes can be spared to make booty in the fields, while at night comb-building progresses apace. Should, however, a much smaller swarm be put in possession of this dome of straw, the bees not only suffer from being weaker in numbers, but from the size of the hive ; for, since they can only half fill it, they are on one side at best but poorly sheltered, and so the weak must give up some of their strength to supply a layer of warming bees (*wb*, A, Fig. 5). Their instinct, singularly, directs them to choose the side of the skep, which thus minimises their disadvantage, by reducing their exposed surface, as will be seen by the curve *c s*, which gives the outline of the same swarm if centrally stationed. It also brings them in contact with the hive entrance, *e*, so that an efficient guard may be kept up without detailing a detachment for the purpose.

It has been thought that, because bees naturally

cluster and work in approximately globular forms, rectangular hives are unsuitable for them. The inference has not much justification if the question be properly analysed. It is true that the globe has a theoretical advantage, since it is the solid which has the smallest amount of surface in proportion to its content. Thus, one cubic foot of bees in globular form would have $4\frac{17}{20}$ square feet surface; in a Stewarton hive (see "Stewarton"), $5\frac{2}{3}$ square feet surface; and in a cubical box (the cube being the rectangular solid with the least surface in proportion to its solidity), 6 square feet surface. But these differences are really insignificant when compared with the benefit derivable from utilising all the bees; *e.g.*, if a swarm be placed in the rectangular hive (B, Fig. 5), wax-workers are able to continue their operations into the very corners, if the walls are only sufficiently non-conductive. The disadvantage here, then, does not arise from the angles, but from excess of space, which is so great that one side of the colony is exposed, and many bees (*wb*) are kept in enforced idleness; while (introducing the principle of elasticity), if the movable side, or dummy (*d*), had been brought up to the line *a b*, the external idlers would have been set free, and converted at once into gatherers and builders, the combs, as a result, growing much more quickly. The dummy here is capable of absolutely adjusting the hive to the size of the swarm, be the latter large or small; so that, in every case, nearly all the bees may be actively utilised in adding to the general wealth.

The position chosen for exit and entrance by all

colonies building in the open shows to us that bees need less protection beneath than on the sides or above, for the heat they produce by their respiratory processes* is gradually carried up, by ascending air-currents, to the spot where their combs are being enlarged, and as these grow downwards the builders descend with them. The heat-preserving layer of bees above is mainly needed to save this warm air from too rapid dispersion, clearly showing the importance of at first limiting the top surface, or roof, of the hive in which a swarm is placed, to the amount that can be actually covered; so that the heated air has no lateral escape, but is held in the requisite position, not by bees, but by the hive itself.

It is true that hives gather no honey, but, in so far as they effect the objects which have engaged our attention, they are the cause of much being gathered; and since hives of very simple construction may in this respect be perfect in action, we admit at once, as the old type of bee-keeper is fond of urging, that bees *may* become as rich and as strong in a skep or box as in the most perfectly-constructed hive of the modern school—*i.e.*, if that hive be left without intelligent management. But we urge that the skep or box bars much of that management which the bee-master finds conducive to his highest advantage; and we therefore turn from the old forms, which no doubt were, in not a few cases, hives for the bees, to those which we regard as hives for the bee-keeper.

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* See "Tracheæ," page 34, Vol. I., and "Wintering," Vol. II.

CHAPTER III.

HIVES FOR BEE-KEEPERS.

Introduction—Huber—Forms of Comb: Laws Regulating its Position—Cutting Combs—Comb Irregularities — Interspace — Stature of Bees—Laws of Bee-space—Huber's Observatory and Book Hives—Fixing Combs—Huber's Artificial Swarming—Plan for Watching Growth of Comb — Dzierzon's and Langstroth's Inventions—The Superiority of Langstroth's Hive—The Stewarton—Storifying Hives — The Carr-Stewarton — Cheshire Makeshift — Standard Frame—Utility of Makeshift, in Queen Raising, as a Twin Hive and in Preventing Swarming—Cheshire Hive, Loose Hinges, Metal Ends—Cowan, Eclectic, Sandringham, Combination, Giotto, and Heddon Hives—The Principle of Inversion.

THE necessities of bee-keeping as an art, together with the desire to investigate the methods of the little comb-builder, and to fathom the mysteries of the economy of her home, have, for the more than twenty centuries elapsing since the time of Aristotle himself, stimulated the inventive faculties of men towards the production of a hive which should permit of handling and scrutiny in all its parts, without involving any

destruction either of the bees or their works. So simple, apparently, are the means by which these objects are attained in the hive of to-day, that it is difficult now to realise the number of the steps by which the goal has been reached, and the amount of effort the solution of the problem has demanded. The progress of the ancients was painful and slow, but it undoubtedly paved the way for the rapid march of the last hundred years. The mournful—and, alas! true—sentiment, that "the evil that men do lives after them, the *good* is oft interred with their bones," happily does not contradict a fact, of which we may be too forgetful, that we inherit, and actually live in the presence of, the embodied thought and effort of the ages: a fact vividly brought before us by a study of apicultural history, bristling as it is with the names of worthies the mere mention of which would fill pages. But due regard to our space and object make it desirable to omit that which, though containing the germs of progress, is yet practically obsolete and valueless, and to commence our studies with the devices of Huber,* from whom the dawn of modern bee-keeping may be considered to date, referring those with historical tastes to "Bevan on the Honey Bee," which gives an excellent summary, and the titles of the works of not a few of the older writers. It is, however, necessary, in order that we may understand the nature of the difficulties to be surmounted, that we should examine the forms bees naturally give to their

* We leave out of view the ancient Greek bar hives, which seem to have been disused and forgotten, and the plans of the Candiotes, from whom Huber is said to have borrowed some of his best ideas on hive-structure.

combs, and bring before our minds two laws of the bee world which have made possible the movable comb hive, as distinguished from the older forms, in which the combs were fixed, and incapable of manipulation.

The nature of comb has been so minutely examined in Vol. I., that it suffices here to point out that the cells containing worker larvæ are of the uniform depth of a bare $\frac{1}{2}$in., the comb being $\frac{15}{16}$in. full in cross section, and that if the midrib (*mr*, B, Fig. 6) be flat, the

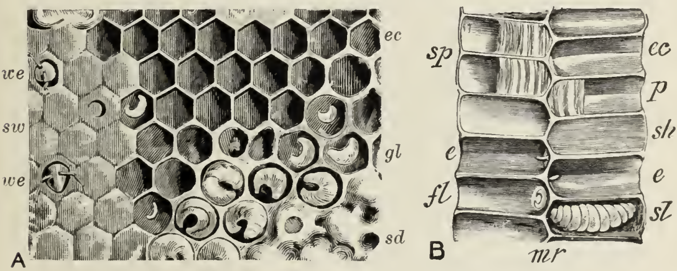


FIG. 6.—FACE AND CROSS-SECTION OF COMB (Natural Size).
A, Comb Face—*we*, *we*, Workers Escaping; *sw*, Sealed Workers; *ec*, Empty Cells; *gl*, Growing Larvæ; *sd*, Sealed Drones. B, Comb Section—*ec*, Empty Cell; *p*, Pollen; *sh*, Sealed Honey; *e*, *e*, Eggs; *sl*, Spinning Larva; *sp*, Sealed Pollen; *fl*, Feeding Larva; *mr*, Midrib.

surface of the comb will, in this case, be equally so. The cells in which drones are raised are deeper, giving to the combs a thickness of about 1$\frac{1}{4}$in. It is often desirable to cut combs without fracture; a dry blade makes very poor work, but if a thin, well-worn dinner knife be dipped into methylated spirit, sections as at B may be obtained without any breaking down of the cell walls. Making such a one, we find the pollen is placed in worker cells, being generally patted down into thin cakes so soon as stored, so that pollens of

varied colours lie over one another in strata, as at *p*, B. Upon these honey is often placed, after which the whole is, for future use, sealed down in the general line of the comb face (*sp*). Although the thickness of comb devoted to brood and pollen is constant, that used for storing honey is liable to great fluctuation, the cells being elongated until sometimes a thickness of 3in., or even 4in., will be reached, as the bees endeavour to fill up vacancies in accordance with their own ideas of economising space, as may be seen at *sc*, B, Fig. 7.

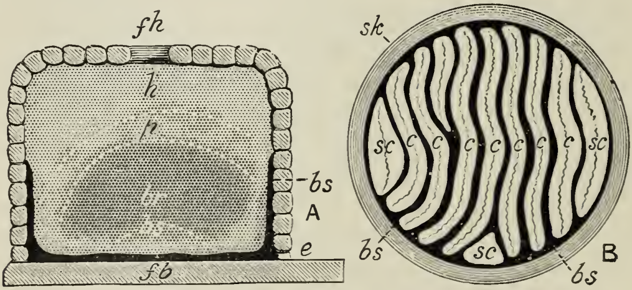


FIG. 7.—STRAW SKEP IN SECTION, SHOWING ARRANGEMENT OF COMBS (Scale, $\frac{1}{12}$).

A, Vertical Section—*fb*, Floor Board; *e*, Entrance; *br*, Brood; *p*, Pollen; *h*, Honey; *fh*, Feeding Hole; *bs*, *bs*, Bee-space. B, Horizontal Section—*sk*, Skep-Side; *c*, *c*, Combs; *sc*, *sc*, Store Combs; *bs*, *bs*, Bee-space.

Even in a shelter that presents no inequalities they never keep the midrib perfectly straight, the latter being always disposed to take a slightly sinuous course, as at *c*, *c*, B; but if they encounter irregularities, the queerest accommodations often arise. The swarm in the privet bush, referred to in the last chapter, had combs of the most whimsical forms, for which space had been found by carving all the leaves from their petioles, while the twigs had been worked in in such

a way as to give the whole structure considerable rigidity.

Combs are started from the upper part of the domicile—*e.g.*, from the roof of the skep, or box hive — those consisting of worker cells only, normally having their midribs rather less than $1\frac{1}{2}$in. apart. The brood comb being scarcely 1in. in thickness, an interspace of nearly $\frac{1}{2}$in. remains, which gives the bees manning the comb on both its faces room to pass each other without molestation, as a worker can squeeze through $\frac{5}{32}$in., and projects about $\frac{3}{16}$in. from the surface on which it is placed; while the stature of the drone is about $\frac{1}{4}$in. The "bee-space," as it is termed, is much lessened between the faces of contiguous combs devoted to honey, as here only room for the passage of a single bee is left. The honey is normally stored above (*h*, A), and at the sides (*sc*, B), where the combs are thickened as a result of what has been already advanced; but the reduced passage-way is preserved, and they are only very slightly, if at all, attached to each other.

The two laws already referred to may be briefly expressed. First: Bees invariably preserve spaces around the lower parts of the ends, and beneath the combs (*bs*, A, Fig. 7), making any one immediately reachable from any part of the floor board, and capable of being ventilated from the hive door. Secondly: Openings between $\frac{1}{4}$in. and $\frac{3}{8}$in. in least diameter, of every shape, and wherever placed, with the single exception of the upper part of the comb, are never closed, but are used as passages:

larger spaces have comb built in them; smaller ones are stopped by propolis.

Huber,* in writing to Bonnet, August 13th, 1789,

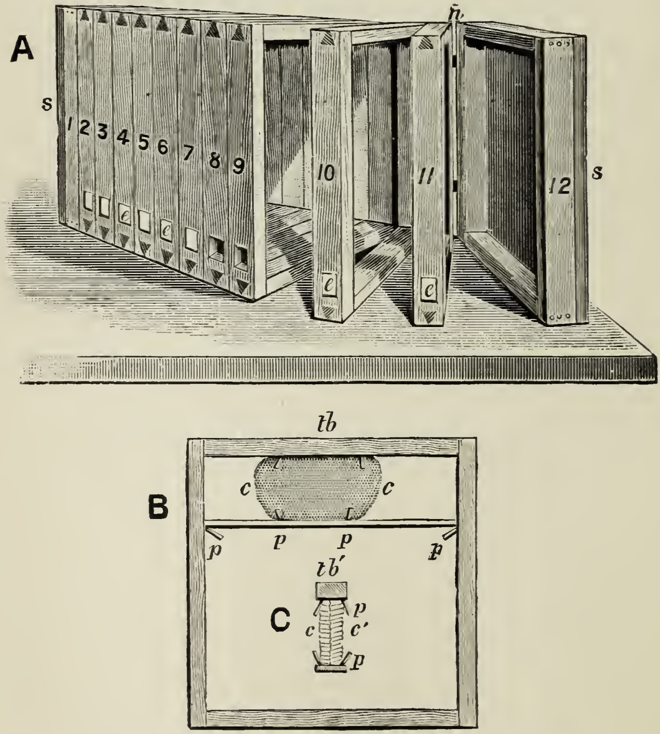


FIG. 8.—HUBER'S BOOK, OR LEAF HIVE, AND PARTS (Scale, $\frac{1}{8}$).
A, Book-hive—*e*, *e*, Entrances; *s*, *s*, Side Leaves; *h*, Hinges. B, Side View of Frame, or Leaf—*tb*, Top Bar; *c*, Comb; *p*, *p*, Pegs. C, Part of Bin, Cross Section; Lettering as before.

points out that, in using an "observatory hive," as recommended by Réaumur, and consisting essentially

* "Nouvelles Observations sur les Abeilles." Unabridged Edition. François Huber, 1814.

of two glass plates, fixed by a frame at somewhat less than 3in. from each other, the bees built *two* parallel combs, instead of the single flat one desired, and so hid their operations from view. To prevent this he allowed no more than eighteen lines* between *his* glass plates, and in this narrow chamber succeeded in establishing swarms, which he had provided with comb already built, as, if left to themselves, the bees, instead of constructing a single large comb parallel to the glass sides, would arrange a number of tiny ones set at right angles to them, so strongly does their instinct revolt against building one comb only. He found that his bees had sufficient freedom of movement, and they could not form in thick bunches upon the comb, as they did where greater width was allowed them. The colonies appeared to be content, and worked with assiduity, while no cell was hidden from view. But, he argues, it might be objected that the natural conditions had been so changed that the instinct of the bees might not have full play. So that, to overcome every species of doubt, he arranged a form of hive which did not lose the advantage of the narrow one, while approaching much more nearly the ordinary shape, in which bees build many combs parallelly disposed. Having procured several deal frames (B, Fig. 8), 1ft. square, and fifteen lines† wide (on which width numbers were put as in the Figure), he united them by hinges (*h*, A), in such

* The French inch being $\frac{9}{8}$ of an English inch, makes this amount $1\frac{11}{16}$in., or only $\frac{3}{16}$in. more than the normal. See page 41.

† Fifteen French lines, $1\frac{13}{32}$in., as nearly as possible—the amount now accounted the best for each comb and interspace.

a way that they could be opened and shut at will, like the leaves of a book, at the same time covering the outside frames by squares of glass (*s*, *s*), which represented the book-covers.

He fixed a small comb on the under side of the top bar of each frame, by means of a little lath, holding all in position by pegs (*p*, *p*) until the bees had attached the comb, when the scaffolding was removed. In the same letter he says: "This hive is, in fact, only a union of several of the very flat hives that can be

FIG. 9.—HUBER'S BOOK HIVE DIVIDED FOR ARTIFICIAL SWARMING (Scale, $\frac{1}{8}$).
e, *e*, Entrances; *s*, *s*, Side Leaves; *st*, *st*, Strings.

separated from each other at will. I admit that one cannot visit the bees in a hive of this sort until they have themselves solidly fixed into the frames their combs, which would, without this precaution, tumble from their places, crushing and injuring the inhabitants, who would be irritated to a most disagreeable extent. You will call to mind that I showed you, when you visited my retreat, a hive of this form which had been a long time in use, and that you

were singularly astonished at the tranquillity with which the bees permitted one to open it;" from which we gather that, practically, the frame hive has been in use for more than a hundred years.

But we must not omit to note that Huber made his hive of practical service, foreshadowing many present methods—*e.g.*, swarming his bees artificially by simple division of the colony. He placed partition boards (*s*, *s*, Fig. 9) in the centre, permitting each half to have an entrance when a new queen was raised in

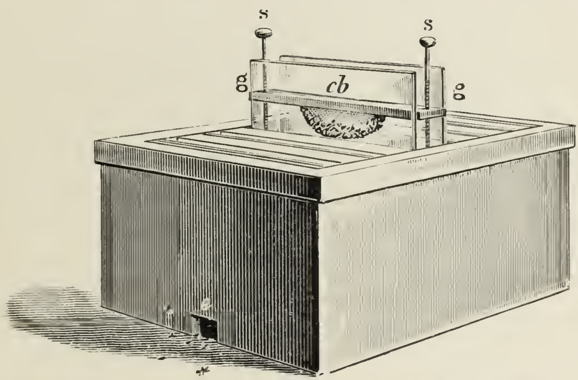


Fig. 10.—Huber's Bar Hive for Studying the Way in which Comb is Built. *cb*, Comb Bar; *g*, *g*, Glass Sheets; *s*, *s*, Screws; *e*, Entrance.

the queenless portion, a method of procedure the merits of which will be hereafter fully discussed. Nor did this remarkable man, who thus gave us a movable comb hive not requiring very large changes to make it greatly like those now used by some advanced apiculturists, fail in contriving an observatory (Fig. 10) which could be supposed to be first cousin to some that have in recent years competed at our shows. His object was to watch the growth of comb.

The top was formed of comb bars (*cb*), between each of which stood plates of glass (*g, g*); two large screws (*s, s*) raised each comb bar when the comb was to be examined. He is not clear in his explanation, but probably the glass plates moved in grooves, and were only allowed to descend a certain distance into the hive body.

The main defect in Huber's hive, the inevitable destruction of bee-life in closing it after examination, remained for a considerable period unremedied, until Dr. Dzierzon, of Carlsmarkt, invented in 1838, and made public in 1845, frames to hang within a box, or hive body, which was manipulated from its side, made to open like a door. In 1851, Langstroth, quite independently of Dzierzon, introduced very similar frames (Fig. 11), which he, unlike Dzierzon, manipulated from above, making his roof movable, and thus securing far greater facility of handling, and giving possibilities of management of which Dzierzon's hive was incapable. Although second in order of time, the superiority of his method has commanded for Langstroth first place in connection with this matter. The frames are hung about ½in. from each other, with the top bar resting on the rabbet, so that the combs stand in their natural relative positions. The employment of slips, triangular in cross-section, at the sides (*s, s*), and under the top bar, was to secure straight combs; but more modern contrivances have made this device needless.

The seed idea of the movable frame—the most pregnant invention ever made in practical apiculture—existed in the leaf of Huber's book-hive, which took

advantage of the first law, already introduced, since, had the bees built their comb to the bottom and sides of it, instead of leaving passage-way, his arrangement would have utterly failed, as the two contiguous faces of adjacent combs would have been cut off from all the rest; but, unlike the more perfect devices of Dzierzon and Langstroth, it derived nothing from the fact that spaces (the bee-space) $\frac{1}{4}$in., or rather more, in least diameter, are allowed to remain open, leaving the frames with combs, honey, brood, and

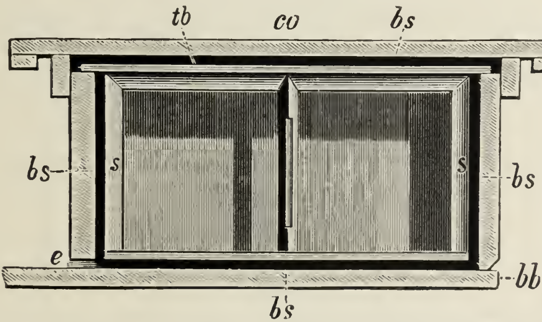


FIG. 11.—SECTION OF LANGSTROTH'S ORIGINAL HIVE AND FRAME (Scale, $\frac{1}{10}$).
co, Cover; *bb*, Bottom Board; and *e*, Entrance of Hive; *bs*, *bs*, Bee-space; *tb*, Top Bar; and *s*, *s*, Sides of Frames.

adherent bees, ever free for examination, removal, passage from stock to stock, or utilisation in fresh and previously impracticable ways; so that the new hives made, even in the hands of their inventors, a new system of apiculture, which has been developing and advancing to the present hour.

The Stewarton (Fig. 12), still much esteemed in Scotland, while it is not without defenders amongst advanced bee-keepers south of the Cheviots, and which consists of octagonal boxes, that may be tiered

one upon another, would have been noticed in this introductory sketch before the Langstroth, since it is said to have been invented about 1819, at Stewart Town,* Ayrshire, by Robert Kerr, who himself adopted the octagonal form from Mewe's hive, dating as far back as 1652, had it not been improved and modified within the last twenty years by "Renfrewshire Bee-keeper," so that it really now contains an adaptation of the Langstroth frame. The lower body, or

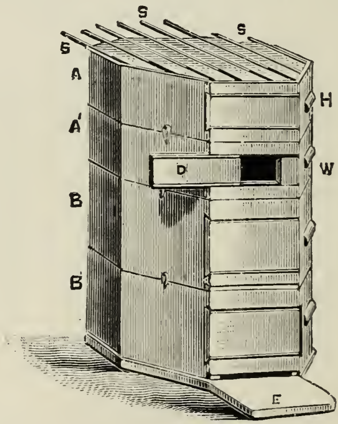


FIG. 12.—STEWARTON HIVE (Scale, $\frac{1}{15}$).
S, S, Slides; A, A', Supers; B, B', Body Boxes; H, Handle; W, Window; D, Door; E, Entrance.

breeding and wintering, boxes (B, B′), are 7in. deep and 14in. in internal diameter, and have eight bars, the six in the centre $1\frac{1}{8}$in. broad, and the two outside ones (where honey is stored) $1\frac{1}{2}$in. Between these run slides (*s*, *s*, Fig. 12), of which the sectional view is given in Fig. 13. By the removal of these,

* See "The Stewarton, the Hive of the Busy Man," by Rev. Dr. E. Bartrum, M.A.

since the combs are fixed to the bars, the bees are admitted from the lower to the upper boxes. The four central combs are surrounded by frames, so that they may be inspected and interchanged with only

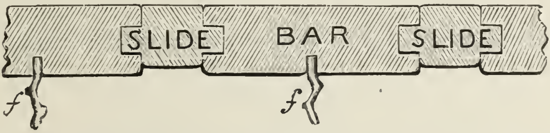


FIG. 13.—STEWARTON SLIDE AND CENTRAL BAR. (Cross-section, exact size.) *f*, Foundation Guide.

little less facility than in ordinary frame hives. The side bars (A, Fig. 14) are shorter, and their ends not rectangular, and have had no frames adapted to them. As a consequence, the combs they carry are fixed to the hive side, and, without breaking or cutting, are not open to examination; to remedy this, I have for

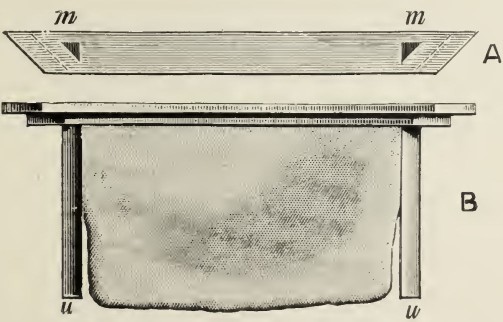


FIG. 14.—SIDE BAR AND COMB OF STEWARTON (Scale, $\frac{1}{6}$).
A, Top View—*m*, *m*, Mortices for Receiving Uprights. B, Front View—*u*, *u*, Uprights.

myself added uprights, triangular in cross-section, which are morticed into the top bar. A bottom rail is not required, and is, indeed, better omitted, as, in its absence, the bees run their comb down to within $\frac{1}{4}$in.

of the floor board (as we see at A, Fig. 7), instead of $\frac{1}{4}$in. above the bottom rail, which must have a bee-space allowed below it (as in Figs. 18 and 19). All the combs are thus made movable; but so cleverly are the slides fixed with propolis (see "Propolis") by the bees, that terrible earnestness is requisite to draw them from their position.

Each box has an entrance cut in its front; but, if two or three boxes are used, the entrance of the lowest is alone left open. "Renfrewshire Bee-keeper" advises increasing the entrance-way, by making similar openings on each side of the usual one.

The octagonal shape is, in the opinion of the same charming writer, an immense benefit to the colony during winter, an opinion which I can only very partially endorse, for reasons given in the previous chapter. The variation in the form of the top bar which it entails certainly prevents the complete interchangeability of combs which a rectangular hive possesses, while it to some extent stereotypes the mutual positions of the combs of any one hive, disadvantages which will hereafter become apparent. The Carr-Stewarton, however, retains the square form, and rejects the unconquerably inconvenient slide, adopting frames like to the Langstroth, while it gives us completely the telescopic character of its prototype—the one feature which has made the Stewarton commendable, and the importance of which is only now beginning to be generally realised. Both of these hives may be extended, by the addition of stock-boxes and supers, to suit precisely the strength of the colony and the yield of honey, while they can

with the utmost facility be compressed as seasonal exigencies may demand. Indeed, it appears to me that, by the addition of a sunk half bee-space in the floor-board of the Carr-Stewarton, and half bee-space above and below the frames of its body-boxes and supers, or section-boxes, a very fair imitation of

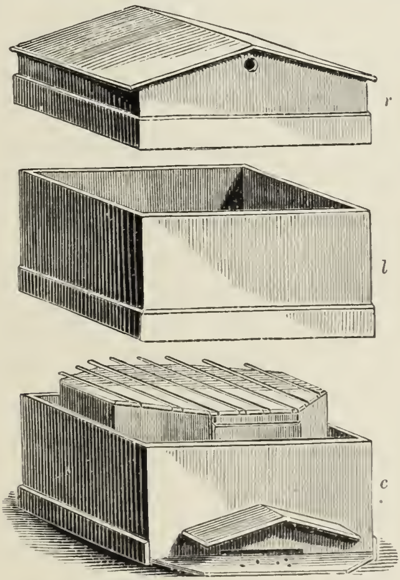


Fig. 15.—Outer Casing for Thin Hives.
c, Lower Cover; *l*, Lift; *r*, Roof.

the Heddon hive (see "Heddon Hive") is obtained at once.

As the correct management of these tiering, or storifying, hives necessitates, during the honey season, repeated changes, not only in the number, but in the order, of the several storeys, these are made light and handy; but, on this account, they are not able to

protect the bees from extremes of heat and cold. It is, therefore, usual to provide them with outer cases, as in Fig. 15. The lower one, carrying a porch, an entrance, and an alighting-board, is covered in winter by the roof (*r*) ; but, as the bees expand in spring, and the hives receive additions of body-boxes and supers, lifts (*l*) are added as may be required. A single body-box will winter well if chaff be packed within the outer case, over and around it. In my own apiary, chaff-boxes (see Figs. 17 and 19) are used with most satisfactory results.

Having looked at main features, it is necessary to pass to details. During the last ten years, some thousands of hives have been exhibited, each supposed by its designer to have some special claim to distinction. In making a selection amongst so many, it is not pretended that the chosen are better than the omitted, but that they appeared to some extent typical, and to present points which were worthy of being brought before the attention of the student. Skeps will *hereafter* be dealt with, as their importance is quite secondary, and as a knowledge of the frame hive will make them and their management the more easily intelligible.

Makeshift hives, as they are termed, find a place in many apiaries, and these may be, in some cases, good enough to afford bees a sufficient home throughout the year. Upon the principle of passing from the simple to the complex, my own makeshift (Fig. 16) is introduced, which, although containing nothing beyond bare essentials, is yet extremely convenient—more so, in some respects, than any hive with which

I am acquainted. Its principal peculiarity consists in its having only three fixed sides, the fourth being a movable dummy, or division-board.

The British Bee-keepers' Association, with the idea of preventing the difficulties arising from every hive-maker choosing some special size, adopted "The Standard Frame," the outside dimensions of which are: 14in. long by $8\frac{1}{2}$in. deep, the top and bottom bars being $\frac{3}{8}$in. and $\frac{1}{8}$in. thick respectively, and the uprights $\frac{1}{4}$in., the width of all sides being $\frac{7}{8}$in. This size has very largely displaced others; but there are signs that progress will lead to this frame being in turn discarded.

Supposing the Standard Frame to be selected, the division-boards (*d*, *d'*), which fit closely all round, must be $14\frac{1}{2}$in. long by $8\frac{7}{8}$in. deep, giving $\frac{1}{4}$in. bee-space at the sides, and beneath the frame $\frac{3}{8}$in., which, at the hive bottom, is not found in practice to be too much. The lugs, or ears (*l*, *l*), will require to be made the same length as the thickness of the hive sides (*s*, *s*). Even those who use the Standard Frame give various lengths to their top bars; if the hive sides be made of 1in. stuff, the top bar of the frame will be $16\frac{1}{2}$in., which is sufficient. It is economy in material to cut the division-board $14\frac{1}{2}$in. by $8\frac{1}{2}$in., nailing along the upper edge a strip $\frac{3}{8}$in. by $16\frac{1}{2}$in., to form the ears. The hive sides (*s*, *s*) will be $8\frac{1}{2}$in. high, and from 20in. to 24in. long; I recommend the latter measure, for reasons presently apparent. Upon these are nailed slats (*sl*, *sl*), extending $\frac{3}{8}$in. above the sides, so as to cover in the ends of the frames. The bottom board (*bb*) need not be thick, and the pieces composing it,

if not tongued, should be halved out as shown. Having cut two division-boards (*d*, *d′*), of accurate size, proceed to nail on one side (*s*), driving the nails from the under side of the bottom board. With the hive still inverted, adjust the second side by means of the division-boards, placed into position so that accurate fitting is secured. Fit on the front (*f*), 8⅞in. deep, cutting into it the door, or entrance, ⅜in. high and not less than 6in. long, not in the middle, but at right or left, so that it opens into the hive at its

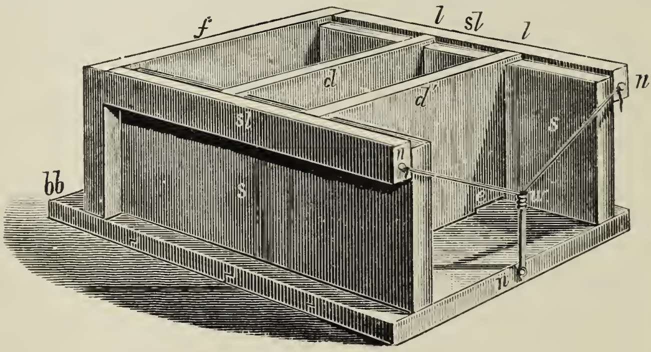


FIG. 16.—CHESHIRE MAKESHIFT (Scale, $\frac{1}{10}$).
bb, Bottom Board; *f*, Front; *s*, *s*, Sides; *sl*, *sl*, Slats; *e*, Entrance for Second Nucleus; *d*, *d′*, Division-boards; *l*, *l*, Lugs, or Ears, of same; *n*, *n*, *n*, Nail-heads; *w*, Wire Clip-ring.

corner. This position has many advantages. To insure the accurate distancing of the hive sides, put the division-board into position, close up to the front piece; then nail the latter on, holding the side against the division-board while doing so. For top covering of this makeshift, any of the styles presently mentioned would be applicable. If it stand in the open, some watertight roof must be provided, the nature of which would depend on the pocket of the

owner; but with such an addition it would winter colonies better than many.

To introduce all the uses to which this hive might be put, would be premature; but let it here be noticed, that it is perfectly elastic, and capable of equally well accommodating a nucleus of two or three frames (see "Queen-raising"), or a full colony, since the dummy (*d*) may be placed in any position. In ordinary hives, close-fitting dummies (which are really the only effective ones) soon become so fixed with propolis that it is difficult to remove them, but here the absence of the fourth side makes it easy. The sides (*s*, *s*) have a certain small amount of play, and, by drawing their free corners somewhat apart, the propolis is cracked, and the division-board made free; carefully rubbing the edges and bottom of the latter with tallow or vaseline once or twice in a season will greatly aid the operation. Since it is desirable that the sides fit closely up to the division-board, they may be tightened up thus: At the free corners and the middle of the bottom board fix round-headed nails (*n*, *n*, *n*), and make a tube-like ring by coiling a piece of bell-wire eight or ten times. Fasten a well-waxed and loose string over the two upper nails. Double the string in the middle, and pass it through the coiled wire (*w*). Putting the centre over the lower nail, and pushing up the coil, will tighten the string, and bring the sides so up to the division-boards that there will be no leak of heated air. A trial or two will determine the best length for the string, but most bee-keepers would content themselves with the two upper nails, over which a string could be fastened very

rapidly. When the division-boards again require removal, or the floor-board is to be cleaned—an operation performed with the greatest facility—slip down the coiled wire, and the string will fall completely out of the way.

This hive will also always be of the accurate size for two colonies, a feature which no other possesses in an equal degree. One with four sides, and with room for twelve frames and a division-board, by example, would leave an awkward gap with colonies, say, of four and five frames respectively, the gap necessitating two division-boards and a separation of the stocks. Thus, their mutual assistance, in tending to keep each other warm, is almost entirely inoperative. But with the form under consideration, the first nucleus has the division-board (*d*) fitted up to it; the second nucleus is then added, and is, in like manner, closed in by the other division-board (*d'*), this having a portion of its corner, ⅜in. by from 4in. to 6in., cut out, so as to form the hive mouth (*e*). As either of these lots increases or diminishes, the hive is expanded or contracted, and always gives the best possible kind of protection. If one colony only, and that requiring food, be placed within it, the division-boards change places, *d'* going next the bees, which are then fed by bottle or comb between *d'* and *d*, in the manner which is the very safest for weak lots, the removed corner giving access to the food, and the outside board (*d*) presenting an impassable front to all inquirers. The absence of the fourth side, then, is not merely an economy or a simplification, but actually augments facility of manipulation: for, with the usual form, as

the stock grows, the division-board is driven to the hive side, so that the fingers cannot get behind it; and when it is crowded out altogether, it must be removed by perpendicular lifting—often a matter of no little difficulty—and a space is generally left, in which the bees build comb against the hive side. But the main utility remains to be considered: it is, that, by giving flight from the removable dummy (*d′*), the hive may be opened without touching the supers that may be upon it; the front combs are thus always at immediate command. To those acquainted with Mr. Simmins's system,* the immense advantage here is at once evident, as, so fast as the bees build up the space left at the entrance, their combs, with a minimum of labour and disturbance, can be displaced, and frames with starters only supplied; and thus swarming is at once efficiently prevented—a matter of the highest moment, to which we shall have to return.

This style of hive, in addition, admits of a variation in structure many would find highly useful, and possibly preferable, to the one figured. The front (*f*) is omitted, and that which is really a division-board is permanently nailed in or near the centre, so that the ground plan resembles a capital H, of which the uprights are the sides, and the cross-piece the permanent division. As the colonies retire upon their stores in the winter, they aid one another in sustaining temperature, and in the spring this mutual assistance facilitates the drawing-out of sections or foundation. The movable fronts may be supplied with handles, if desired, and there is no occasion for them to reach the

* See "Original Non Swarming System," by S. Simmins.

bottom, as the door may be left the whole hive width stopped by Langstroth blocks—*i.e.*, two triangular pieces so placed before the opening that they cover much or little of it, as desired. If metal runners (see Fig. 22) be added, the front had better have the

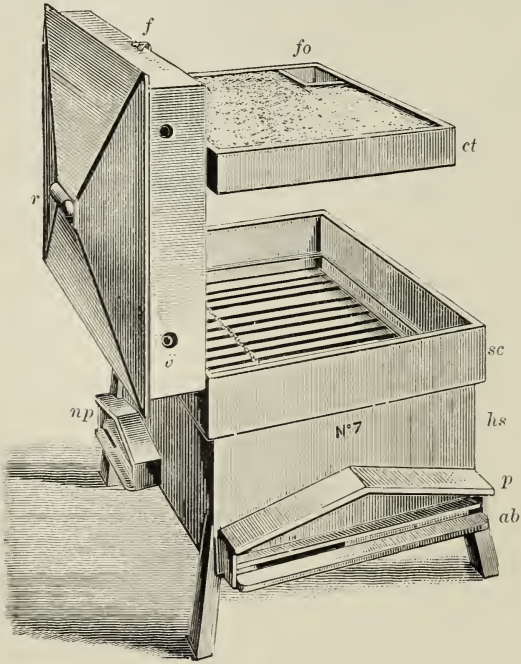


FIG. 17.—CHESHIRE HIVE (Scale, $\frac{1}{12}$).
hs, Hive Side; *sc*, Super Case; *p*, Porch; *ab*, Alighting-board; *np*, Nucleus Porch; *ct*, Chaff-tray; *fo*, Feeding Opening; *f*, Fastening; *r*, Roof; *v*, Ventilator.

space lying between the runner and the hive side filled by a wedge cut to shape.

Let us turn to a form in which completeness has been the aim, and in which the well-being of the bees and the comfort and convenience of the manipulator

have been consulted in preference to any question of cost. The hive here illustrated (Fig. 17), and made by Mr. Holland, closely resembles the one devised and generally used by the Author, and so has his name affixed to it, although it differs considerably from an earlier pattern bearing the same designation. It stands on splayed legs giving it a firm base and a height suit-

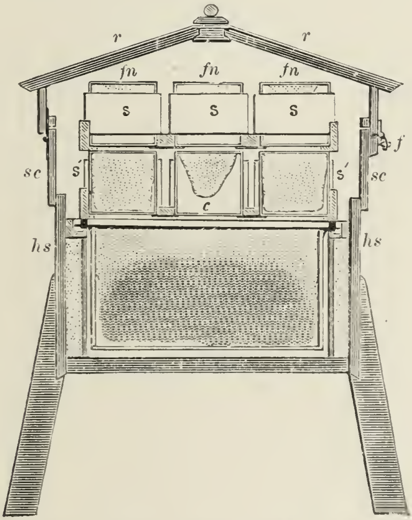


FIG. 18.—CHESHIRE HIVE DURING HONEY HARVEST. SECTION FROM SIDE TO SIDE (Scale, $\frac{1}{12}$).
c, Comb; *s*, *s'*, Separators; *fn*, *fn*, Foundation; other Letters as before.

able to the operator. These legs are painted on the end grain several times, at intervals, and then have zinc plates fixed upon them, so that rotting is for many years quite prevented. The sides (*hs*, *hs*, Figs. 18 and 19) are double all round, with an interspace of 1in., packed firmly with cork-dust, which the writer's experiments (see "Wintering") have proved to give fourteen times

as much protection as dead (?) air, upon which so much reliance was formerly placed; for, if the two skins of wood inclose only air between them, a constant circulation is kept up—the air rising on the side next the bees, to be replaced by that which has cooled by contact with the outer skin—and thus heat is being

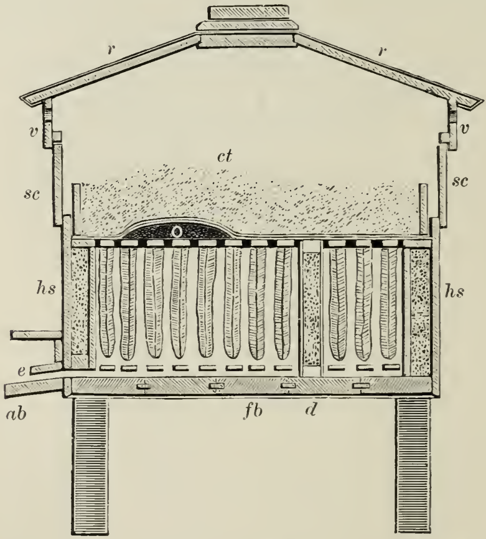


Fig. 19.—Cheshire Hive prepared for Winter. Section from Front to Back (Scale, $\frac{1}{12}$).

fb, Floor Board; *e*, Entrance; *d*, Division-board; *o*, Cake; other Letters as before.

unceasingly dissipated. Cork-dust, in consequence of these experiments, is now being used by many makers. The frames are usually of the Association standard size, and are twelve in number; but the hive is perfectly elastic, as the close-fitting and cork-packed division-board (*d*, Fig. 19) permits of the colony being restricted as their strength and the season may demand. Over the

frames is placed waterproof cloth, a piece of Hessian, or unbleached calico, according to the season; while, at all times when two supers are not on the hive (see Fig. 18), a chaff-tray (*ct*, Figs. 17 and 19)—unspeakably superior to carpeting—is used over the frames. This chaff-tray consists of a ring of wood, 3in. or 4in. deep, with a bottom of rather loose sacking; so that, when it is placed in position, the chaff beds itself down completely over the top of the hive, fitting any irregularity, and preventing all needless leak of heated air. Fig. 19 shows *o*, a flour cake, under the chaff-tray, and explains the statement just made. The loss of numberless colonies is no doubt traceable to defects in the top covering, the non-conductive qualities and close fitting of which are far more important than those of the hive side itself. A rim of wood (*sc*) gives considerable shelter to the bees during any manipulation in windy weather, while it so places the roof-piece that the latter can still be opened and closed on hinges if a doubling-box carrying eleven Association Standards, or two supers (Fig. 18), rest upon the ordinary frames. The roof-piece is hinged, and has a short chain attached to it, so that it is retained at a right angle to its closed position (see Fig. 17), thus affording ample table-room for necessary tools, such as the smoker or spray-producer. When the roof-piece is shut down, the fastening (*f*, Figs. 17 and 18) acts automatically. It consists of a brass ring, with a screw-plate, fixed to the roof-piece, and a horizontal ring on the super case. One springs over the other at the moment of shutting, and prevents the possibility of wind opening the hive; while a padlock may

be added at the owner's discretion. The roof (*r*) is covered with zinc, with wood beneath it; the zinc being everywhere free, as seen in Fig. 19, it cannot buckle or tear by expansion or contraction; while the whole so shuts as to be absolutely bee-proof, a point which should be reached in every well-constructed hive. Every facility is afforded for raising a queen in a nucleus, besides accommodating the stock, as the tight-fitting division-board (*d*, Fig. 19) completely separates the nucleus from the parent colony. Two frames would be sufficient for the former. Its entrance is placed at the angle *np* (Fig. 17). The manipulator stands behind the hive; the bees of the main colony flying from him as they pass from their entrance, while those of the nucleus are saved from troubling by the roof-piece, which provides its table room on the right-hand side. If feeding be needed, a corner of the thin cover is turned back, and a bottle given at the opening *fo*, the bottom of which is fitted by a pierced block, over which Mr. Holland adapts a feeder, illustrated subsequently. Should the food be required by the nucleus, the chaff-tray stands as in Fig. 17; if by the main colony, the chaff-tray is turned round. Feeding, however, would rarely be required during the time the nucleus was at work, and so the main colony, if in need, may be generally fed behind the dummy, as hereafter described. The comfort of this hive consists not a little in its self-contained character; it is the same summer and winter, and for wintering qualities it is impossible to excel it—without wraps to stow away, or carpets to be piled on as winter draws near. It is all the year capable of being opened and

closed at once, with a certainty that every part will fall into position, and discharge the function required of it. The details of the method of using this, or any of the other hives figured, could not here be given without covering ground which properly belongs to other chapters, but two or three structural points need explanation now; *e.g.*, the Author does not hinge his hive cover, as in Fig. 16, for a loose cover has one or two advantages worth retaining—to name one only, it admits of tiering up to an unlimited extent.

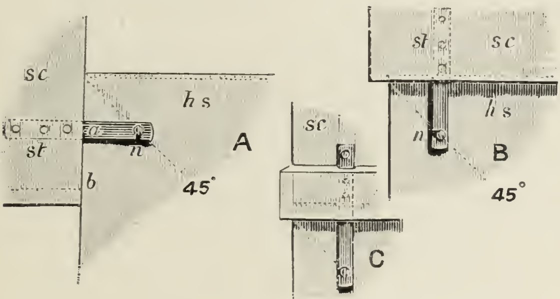


FIG. 20.—LOOSE HINGE FOR HIVE ROOF (Scale, $\frac{1}{8}$).

A, Portion of Hive, open—*sc*, Section Cover or Roof-piece; *hs*, Hive Side; *st*, Iron Strap, or Loose Hinge; *n*, Notch for Screw. B, Same shut—Lettering as before. C, Loose Hinge applied to Hive, with Plinths—Lettering as before.

Mr. Green, some years since, exhibited the first loose hinge; but it was both weak and difficult of application, and so the Author devised the plan which Fig. 20 will make clear.

Iron straps (*st*, A), $\frac{3}{4}$in. wide, 6in. long, and $\frac{1}{10}$in. thick, have three screw-holes bored and countersunk towards one end, and a notch (*n*) cut near the other. The straps—a pair to each hive, and on opposite sides of it—are fixed by screws so that the middle

line of each is the same distance from the inner angle of the super case as its notch is from the lower edge of the same—that is, the distance $ab = an$; 2in. will be found to be ample. The screw upon which the strap turns must be the same distance (2in., *e.g.*) from the back of the hive body, and just so much more from the top edge of the hive as the super case laps over it. To remove the roof, it only needs to be lifted—when open, as at A—and the screws slip from their notches, and leave all free. The plinthed hive will be treated as at C, the plinth having a part chiselled out on the inner side, to admit the strap. The extreme comfort and convenience of this arrangement can only be understood by those who use it, and it only needs to be known to be extensively adopted. There is nothing to place on the ground; the hive is opened and closed instantly, without possibility of error, and fastened automatically withal; no chain to offer any impediment to the hands; and a table provided capable of carrying chaff-tray and every requisite. With the loose hinge, the part *sc* (Fig. 17) is not necessary, as the roof-piece may be made of any depth. If doubling-box or supers, or both, be upon the hive, it is only necessary to lift the roof-piece from its loose hinges, and then place it over the honeyed tower.

The frames of this hive, unlike those used by the Author, are supplied with what are called metal ends, of which several forms are in use; one, which may do duty for all the rest, is represented in Fig. 21.

The object of these metal additions is to keep the frames at their proper relative distances, to preserve

the bee space, by means of the triangular strut (*ts*), which holds the frame (*fs*) at ¼in. from the hive side; and to prevent the bees passing to the ear, or lug (*l*, *l*, A and B), so that the part by which the frame is handled may be kept clear of propolis. This substance often annoys the bee-keeper greatly, for, in some localities, it is gathered in such abundance that frames of the usual kind so glue the fingers that work is seriously impeded, while the skin is disagreeably stained, even after the resinous body has been removed by the method explained under "Propolis."

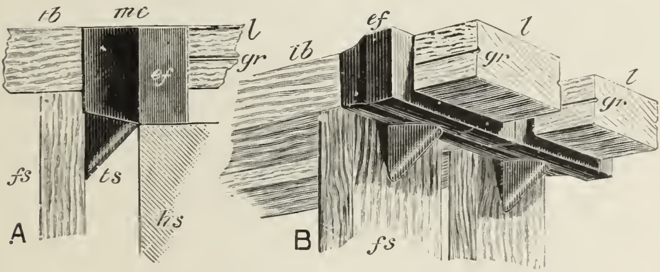


FIG. 21.—METAL ENDS FITTED (Full Size).
A, Side View—*me*, Metal End; *ef*, End Face of Ditto; *ts*, Triangular Strut; *tb*, Top Bar of Frame; *l*, Lug, or Ear; *fs*, Frame Side; *hs*, Hive Side; *gr*, Groove. B, Perspective View of two Metal Ends—Lettering as before.

The rapidity with which these novelties have gained favour is perhaps explainable by their possessing the last-stated advantage, great in itself, yet, as I venture to think, almost the only one with which they can be credited, and which may be fully secured, as shown at B, Fig. 22, by more simple and less costly means. It is certainly claimed that they protect the colony during winter, but it is evident that their power of retaining the heat the bees generate is at best but exceedingly small. Disregarding their considerable

cost, their disadvantages are numerous. At first they work freely, but every time a frame is moved the propolis is drawn out into strings, to be squeezed flat between their adjacent faces (*ef*) when the frames are once more pressed into position, until the latter become literally fixed, and can only be freed by a wrench, which irritates the stock, and in turn disturbs the operator. Bees getting beneath the lower side of the metal end, as the frame is replaced, cannot be seen, and so crushing is inevitable. Others, again, are jammed between the "ends" themselves, unless much time be taken; while not a few remain between and beneath the lugs, to be imprisoned and perish if the quilt be put on over them. So great is the contact surface, that the least propolisation prevents the frames being pushed backwards and forwards in number; while it will become apparent, during our progress, that keeping the frames at a stereotyped distance is more a fault than a virtue. When the extractor is used, the metal end must be removed and replaced; yet it is true that this, though troublesome, is not a matter of difficulty, as projecting edges are cast on the interior faces; so that, as the "end" is pushed on to the ear, grooves (*gr*) are cut into the yielding wood, permitting it to be easily slipped off, and returned to its position, fixed for all practical purposes.

About fourteen years since, the Author introduced the metal runner (*mr*, Fig. 22), consisting of a strip of stiff tin or zinc, nailed to the hive side, and raising the frame end ¼in., practically stopping propolising on the under side of the lug. In those days, a crown board—*i.e.*, a wooden cover, was used instead of

the quilt (*q*), giving a space above the frames of fully $\frac{1}{4}$in., so that propolisation only occurred between the hive side and the end of the ear. To reduce this, the Author cut off the frame end at an angle of about 45°. Both of these plans have been extensively adopted, along with the wire nail distance-keepers, which were placed at the opposite sides and ends of the top bar, very near to the upright of the frames, which by this arrangement fitted equally well in any order, and with either face of each comb towards the operator. These distance-keepers may be either panel-pins, bell-hangers' staples (*ds*, B, Fig. 23), or screw-rings projecting far enough to keep the combs at the determined distance from each other. Thus arranged, the frames can be slidden backwards and forwards, either singly, or five or six at a time, and any one removed without jar, or the smallest risk to a bee.

In reference to the tin runner, the advantages of which to the operator are so apparent, a want of scientific knowledge has given voice to a statement that metal is injurious inside a hive, because it conducts away the heat. Metal would, undoubtedly, act prejudicially if only *partially* within; the warm air in such a case giving up its heat to the metal, which would readily part with it to the air without. If the metal strip be wholly within the hive, however, it stands at the temperature of the interior air, from which it can, in consequence, abstract no heat. In a frosty atmosphere, *e.g.*, if a half-crown or other coin be held between the thumb and finger, the metal will quickly cool them to numbness; but if the coin be placed in the palm, and covered by the fingers, its

presence, after it has reached the heat of the hand, will in no way affect temperature. It is true that, in winter, the part of the runner nearest the cluster will be slightly warmer than the rest, and that it will tend somewhat to equalise temperature; but the conduction from this cause is so infinitesimally small as to be practically *nil*. Both tin (iron) and zinc stand low down as conductors amongst the metals, and, in addition, their capacity for heat is not more than a tenth of that of water; or it may be stated, for the benefit of those unacquainted with the scientific bearings of the matter, that it would require as much heat to raise 1 oz. of water through any number of degrees, as would be absorbed by 10 oz. of either of these metals. Thus, then, syrup holding 3lb. of water, and given as food at the heat of the external air, would abstract more heat from the cluster of bees than ¼cwt. of zinc placed cold in their midst. But metal runners, while hanging frames are used, may be safely left to take care of themselves; let us, therefore, see how we may obviate the propolisation on the ear, which the use of the quilt now occasions.

The Author has had made, for experimental purposes, some reversible—or, more correctly, invertible*—frames, which have led to a solution of the difficulty, by the substitution of a thin iron lug (*il*, B, Fig. 22) for the wooden one. For this purpose, nothing seems to excel hoop-iron No. 19, ¾in. wide. This is thin enough to be bent to shape while cold, and

* These frames permit of the bottom of the contained comb being made the top, and so should be called invertible. The word "reversible," implying that the front may be turned to the back, is here inapplicable, and should be discontinued.

is at the same time so rigid that no ordinary wear and tear can damage it. For a simple ear, a piece 2½in. long is cut. One inch of this, or as much as the thickness of the hive may make desirable (*a*, *b*), is placed in the vice, over an iron block to which a ¼in. bevel has been given; a few blows with the hammer will form it, care being taken that the bends are made at right angles to its length. With the part *a*, *b*, placed on a level with the bottom of the top bar, it is

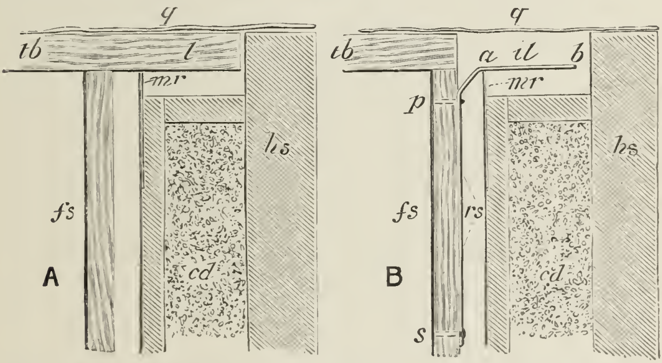


FIG. 22.—METAL RUNNERS AND EARS (Ordinary and Anti-propolising), (Scale, ½)
A, Ordinary Frame End—*tb*, Top Bar; *l*, Lug; *fs*, Frame Side; *q*, Quilt; *hs*, Hive Side; *cd*, Cork-Dust Packing; *mr*, Metal Runner. B, Anti-propolising and Invertible Frame End—*il*, Iron Lug; *rs*, Inverting Strap; *p*, Pin; *s*, Screw; other Letters as before.

nailed, through holes previously punched, to the frame side, over an iron block, so that the nails are clinched. The bevel gives the form, standing at 45° between *a* and the pin *p*, and which acts as the triangular strut (*ts*, Fig. 21) of the metal end, accurately keeping the frame side ¼in. from the interior of the hive. It is clear that this lug, when in position, will stand away from the quilt (*q*, B) only its own thickness less than that of the top bar, and,

as a consequence, that no propolisation will occur, except at the point immediately below *a*, which does not come into contact with the fingers.

But another advantage may by this form be secured: if it be intended to make the frame invertible, the perpendicular part of the attached hoop-iron, instead of being short, and firmly nailed, is cut rather more than half the depth of the frame, the centre of the side of which is carefully found and marked, and the hole for the screw (*s*) drilled. The hoop-iron is turned up as before, and receives two holes, the first carefully placed, and countersunk, so that, when the screw (*s*) passes through it, the part *a*, *b*, may stand, as previously remarked, on a level with the under side of the top bar of the frame. The second hole is to receive and loosely pass the pin (*p*). After the screw (*s*) has adjusted the strap, so far as depth is concerned, the pin (*p*), in the form of a wire nail, is driven through the hole made to receive it, until fixed firmly in the frame side, when the head is cut off, by cutting-pliers, at the external surface of the strap. The strap, in virtue of its slight pliability, can be immediately lifted off the headless pin. It now receives a half rotation on the screw (*s*), so that it lies along the lower half of the frame side. A second wire nail is driven through the vacant hole, and decapitated as before. The strap can now be returned to its former position, in which the pin, by passing through the hole, will retain it. Two straps being fixed at the opposite ends make the frame forthwith most completely invertible, while, at the same time, the holding of it by the ears keeps the straps

close to the frame sides, and firmly fixed by the upper pins. All ordinary frames permit thus of at once being converted into those that are both anti-propolising and invertible, the only alteration required being the removal of the existing ears, and the fixing of the straps. This can even be accomplished in those that are furnished with combs, if fine screws be used instead of wire nails for the pins, the heads of the screws being, of course, removed. By the use of this device, all that recent theories have seemed to make desirable, is attainable, while, as before said, the fingers remain unsullied; and so small is the propolisation between the metal of the runner and that of the ear, that the slip movement is deliciously smooth and easy.

A question remains for settlement: Shall we use distance-keepers of any kind? They *have* their advantages, and facilitate manipulation much, where propolisation is sufficiently guarded against to permit several frames to slide laterally by reasonable pressure. For these I know of nothing superior to my old arrangement—the bellhangers' staple, fixed as explained at page 67—except, possibly, the screw-ring which Mr. Sproule has substituted for it. Some have murmured that these tear the face of the combs; but such may safely be regarded as belonging to the small class who would object to chisels because they cut one's fingers. The bee-keeper of small experience *must* depend on a distance-keeper; he who has become an expert *may* do better by dismissing them all. His combs must then be placed *singly*, by eye, and those who are bad judges of

measure might mark on the hive side the normal position for combs and interspaces. Although several of my hives have no distance-keepers, yet my own preference lies now with one extending $\frac{3}{8}$in. only from the frame of $\frac{7}{8}$in. wide, so that a minimum of $1\frac{1}{4}$in. is preserved, when no accident permits of the frames jamming together, and crushing the bees in the brood nest. Such distance-keepers, at the same time, do not interfere with those variations in interspace which recent observation has shown to be desirable; *e.g.*, swarms and stocks furnished with guides $1\frac{1}{4}$in. apart are compelled to build *worker* comb (see "Swarms"), to the exclusion of drone. If the raising of brood, and consequent increase in the number of bees, be the object, a reduction in the usual interspace, in all but the coolest weather, leads to most satisfactory results. If foundation be given, similar management quickens the drawing out, and increases the surface operated upon, while it considerably reduces the chances of stretching. There are other cases in which *increased* distance is required, to which the devices referred to present no impediment; these, therefore, had better be noted while dealing with broad-shouldered frames.

Bees are small creatures, and our attempts at separating them into two or more lots in one hive may end in disaster through any defects in the division-board. Accurate fitting is also demanded, because air flows with surprising quickness through small gaps, handicapping seriously weak colonies, which may thus lose the heat that they, even under favourable conditions, maintain with difficulty.

The division-board the Author has found most perfect in its action is seen in Fig. 23. Two thin boards are kept about ½in. apart by wooden slips. Upon the outer edges of those intended to occupy the sides, strips of cloth (*cp*, C), six or seven in number, are fixed by long, thin nails, as at *a*. The slips are placed between the boards, so that the strips of cloth are doubled, with their edges outwards (*b*); these are cut to form with a straight edge and keen knife, and then planed down until the size to

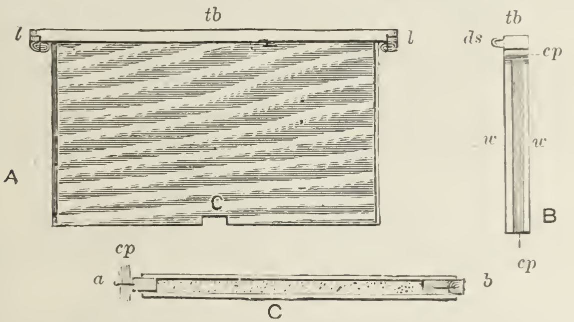


FIG. 23.—CORK-PACKED DIVISION-BOARD (Scale, ⅛).
A, Front View—*tb*, Top Bar; *l*, *l*, Lugs, or Ears, with Cloth Packing. B, End View—*tb*, Top Bar; *ds*, Distance-staple; *cp*, Cloth Packing; *w*, *w*, Wooden Sides. C, Top View, Top Bar removed—*cp*, Cloth Packing.

fit the hive is obtained. The bottom slip is afterwards added, the space being packed with cork dust, and the top bar fixed on. A strip of cloth, rolled up, is next fastened under each lug (*l*, *l*, A), and the board is complete. The thickness of the face-boards which come near to the hive side prevent the bees reaching the cloth, so that the latter is not propolised; and if a little oil, or, better, vaseline, be placed upon it, the movement of the board will be for a long time both easy and agreeable.

The bee-keeper may have occasion, not only to divide his bees into separate lots, under one roof, but actually be necessitated to confine one or more of the individuals of a colony of which the others are necessarily left free. One example will now suffice: The queen unimpeded may travel to the combs which we have in idea fondly devoted to table uses, and there deposit eggs, interfering with our notion of the

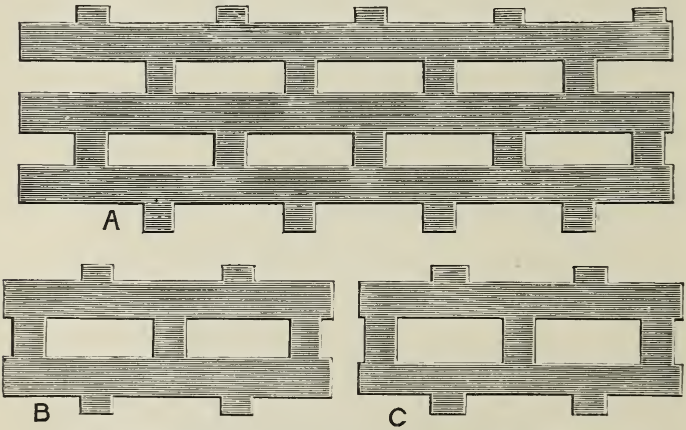


FIG. 24.—A, QUEEN-EXCLUDER ZINC (least size, to pass Workers). B, Passes Queens, but not Drones. C, Passes Drones.

fitness of things, by changing the larder into a nursery. The more bulky body she possesses, as compared with the workers, enables us to restrict her meanderings while her attendants enjoy the fullest liberty. This is now accomplished by what is called "excluder-zinc," or "queen-excluder," the varied methods of employing which will require, subsequently, detailed explanation. A worker, when loaded with honey, can just traverse a hole $\frac{5}{32}$in. in least diameter, which must

be made quite $\frac{1}{32}$in. more to give passage to even an under-sized queen. Slats of wood, carefully placed, or wires accurately distanced, have for a lengthened period been in occasional use to prevent the queen's unwelcome visits; but the more convenient, and withal reliable, form (A, Fig. 24), just now referred to, has of late years been extensively employed. It consists of sheet zinc, with oblong* perforations about $\frac{11}{64}$in. in width, and a full $\frac{1}{2}$in. in length. This material, used as a diaphragm, while no obstacle to the workers, should present to the queen an impassable barrier, and, doubtless, in all cases would, but from the general want of truth in the size of the openings. Several specimens the Author has measured give every variation between $\frac{5}{32}$in. and $\frac{6}{32}$in., and even these limits are occasionally exceeded. The result is, that many unimpregnated, and a few impregnated, queens may escape through it—a considerable practical disadvantage, which has much impeded some experiments related under "Queen Raising," and which would not appear to be unpreventable, since there can be nothing in the process of perforating which makes accuracy unattainable. Reference to the Figure, showing holes (B) that will retain drones but not the queen, or will permit all to pass (C), while those in A are of the least diameter that will allow a worker to escape, will make the necessity of care in this matter the more evident.

* Mr. O. Poole, many years since, placed ordinary perforated zinc, having circular holes, $\frac{5}{32}$in. in diameter, between his hives and his supers, and achieved considerable success; but the French gave us the form now universally adopted, by making the perforations oblong (see *British Bee Journal*, June, 1875, page 31; August, 1877, page 68; April, 1878, page 212).

Fig. 25 represents, in section, the Cowan hive, the substance of the description of which, as given by the inventor,* is here reproduced. It consists of a body-box (*hs, hs*), of 1in. pine, arranged to take from ten to thirteen frames, of the Association standard size, and which rest on two tinned-iron strips, fitted to the rabbets of the front and back. B, the floor-board, of $1\frac{1}{4}$in. pine, is strengthened by means of two wooden

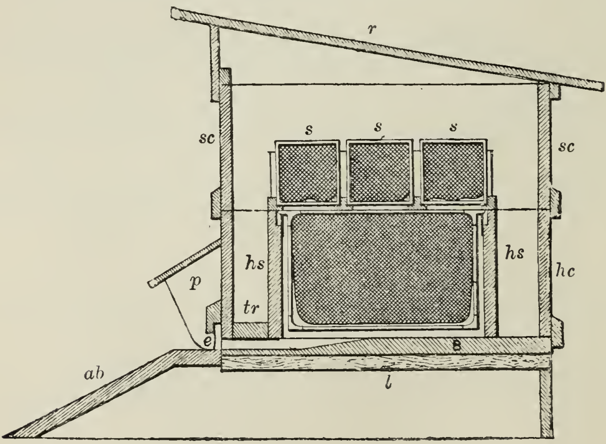


FIG. 25.—SECTION OF COWAN HIVE (Scale, $\frac{1}{12}$).

ab, Alighting-board; *e*, Entrance; *tr*, Tunnel Roof; *p*, Porch; B, Bottom Board; *l*, Ledger; *hs, hs*, Hive Sides; *s, s, s*, Sections; *hc*, Hive Case; *sc, sc*, Super Case; *r*, Roof.

ledgers. The entrance (*e*) leads into a passage, $\frac{1}{2}$in. deep and 8in. wide, formed between the hollow cut from the floor-board and the tunnel roof (*tr*), which prevents the bees escaping into the outer case. The latter is of deal, $\frac{5}{8}$in. thick, with its lower division (*hc*, the hive case) resting on the floor-board, and carrying the porch.

* See "British Bee-Keeper's Guide Book," by T. W. Cowan, F.G.S.

The lift, or super case (*sc*), is surmounted by the roof (*r*), fitting loosely over *sc*, and having an inclination towards the back, to allow rain to run off. It is covered with paper-felt or calico, and painted to make it waterproof.

Beneath the porch (*p*), a rabbeted piece permits two shutters to slide, so as to contract or enlarge the entrance. The alighting-board (*ab*), 15in. wide, slopes to the ground, and is fixed to the stand, which is 6in. high. The alighting-board, from its position, saves many bees, which would otherwise be lost if blown down by high winds when returning. Root's metal corners are used, as may be seen at the angles of the frames in the illustration. They consist of tin plate bent up into form, and give the frames great rigidity. As in cross section they are like an inverted U (∩), it is impossible to stick them fast, at the same time that the risk of crushing bees is reduced to the smallest limits; but, of course, as in the case of ordinary wooden ears, they are propolised to the quilt at their upper part, to the great discomfort of the operator.

In this hive there are neither distance-pins, notches, nor broad shoulders, securing the advantages arising from variability in the interspacing of comb previously pointed out. Division-boards are used which fit the hive at the sides, but allow ¼in. beneath during the summer months. For wintering, they are made to fit tight by having strips of cloth tacked round the edges on the outside, by which the hive space can be contracted without loss of heat.

All the parts being separable, the hive can be easily moved or examined, or turned in any direction

on the floor-board, which can be readily cleaned or exchanged. The outer case being in two storeys, there is ample room for doubling, and a third storey may be added if more space is needed.

To prepare this hive for winter, the frames are reduced to six, on each side of which are placed the tight division-boards previously mentioned. The spaces outside the division-boards, and inside the hive body, are filled with chaff. On the top a chaff-tray is used, such as the Author has so earnestly and so long recommended, while chaff is poured down around the hive until the outside cover is filled to above the level of the frames.

A hive well worthy of attentive study is the "Raynor Eclectic," with a description of which the Author has been favoured by the inventor, the Rev. G. Raynor, M.A. This hive has its parts displayed in Fig. 26. Its walls are made of double pine, with cork-dust packing. It is divided into two compartments, the entrances of which, at its opposite ends, extend its entire width, and are provided with slides. The front, or brood compartment (*bc*), is fitted with twelve frames, of the Association standard size, and can also accommodate four section-holders, each containing three 1lb. sections, two of the holders being intended to be placed upon each side of the brood chamber, standing one upon the other. Two double division-boards (*db*, *db*), packed with cork dust, are provided, for reducing the size of the hive, and affording protection in winter. The after part (*ac*) is separated from the front by zinc excluder (see Fig. 24), covered by a shutter, and is supplied with three frames, by

means of which it may be used as a nucleus for queen-raising.

When not required for this purpose, the shutter is removed, and the vacant space caused thereby is filled by sections in a wide frame, allowing bee-spaces beneath and on the sides; and the after compartment (*ac*, Fig. 26) is occupied by four more section-holders, corresponding with those in front—the whole interior of the after part being thus utilised as a honey compartment, the back entrance being closed. Above the

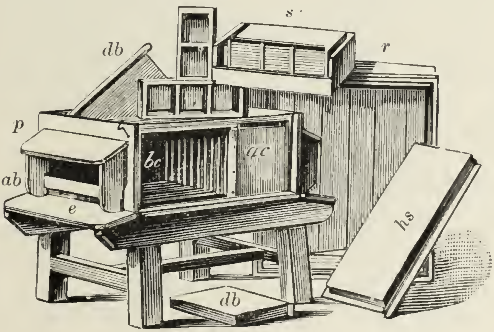


FIG. 26.—THE RAYNOR ECLECTIC HIVE (Scale, $\frac{1}{20}$).
bc, Brood Compartment; *ac*, After Compartment; *ab*, Alighting-board; *p*, Porch; *e*, Entrance; *hs*, Hive Side (movable); *db*, *db*, Division-boards; *sr*, Section Rack; *r*, Roof.

frames of the brood compartment is placed the section-rack (*sr*), which receives the eight section-holders from below, each with its three 1lb. sections; so that, when these sections are fairly commenced in the front and after compartments, the holders, with sections and bees together, are transferred to the case above, while empty ones take the places from which they have been removed. The brood frames are fitted with metal ends (see Fig. 21), and slip freely upon hard-

wood runners. Both sides of the hive are movable, and frames can be taken out on either hand while the section-case is in position. The hive, which is substantially built, on a strong stand, with stout legs, and covered in by a capacious and well-ventilated roof (*r*), may be considered as a type of those hives which accommodate both a full colony and nucleus.

Messrs. Neighbour have recently exhibited a hive, called by them the "Sandringham" (Fig. 27), moderate in price, yet still substantial in build, and having a modification which may be found of considerable service. To this alone special attention will be called, since the Figure will be, in other respects, intelligible in the light of previous descriptions. The doubling-box (C), which is as nearly as possible square in plan, is sufficiently large to slip completely over B (the hive proper). To prevent it actually doing so, strips (of which the sections are marked *s*, *s*) are nailed on within it, about 1½in. from its lower edges. By means of these the upper storey rests upon the top faces of the hive sides. Of course, the doubling-box would be too capacious to carry the frames, so two sliding parts (*sl*) are run down in grooves, as at C′. These reduce the width to just 14½in., and give above the usual frame accommodation, making the doubling-box into a second hive, into which standard frames fit, and which could be actually independently used with an adapted bottom board. The doubling-box is placed in position, and combs are added, if extracted honey be the object. At the close of the season, the bees are reduced to the limits of the hive proper, when the slides (*sl*) are drawn out, the porch is detached from

its place, where it is held by two thumbscrews, and fixed, upside down, upon the doubling-box, which is now inverted, and slipped over the hive, as at B′, C′, until the aforesaid internal strips arrest its further descent. Instead, then, of the doubling-box becoming an extra article of bee furniture, to be housed during

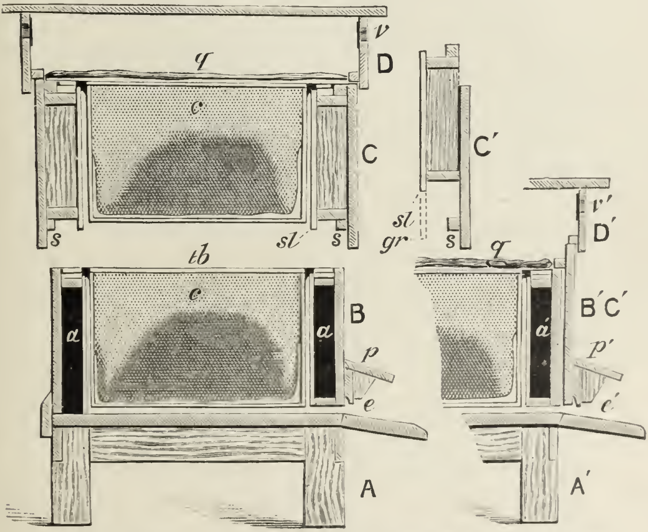


FIG. 27.—SECTION AND DETAILS OF SANDRINGHAM HIVE (Scale, $\frac{1}{12}$).
A, A′, Stand; B, B′, Hive Body; C, C′, Doubling-box; D, D′, Roof; *e*, *e′*, Entrance; *p*, *p′*, Porch; *c*, *c*, Combs; *a*, *a*, *a′*, Dead Air Space; *tb*, Top Bar; *q*, *q*, Quilt; *sl*, *sl*, Slide-piece; *gr*, Groove; *s*, *s*, *s*, Stops; *v*, *v′*, Ventilator.

the winter, it does duty in affording the colony additional protection in the time of need, the roof (D′), placed over all, giving storage space for the removed sliding pieces. If the hive be run for comb honey, section racks (see Fig. 18), instead of frames, are placed in the upper storey, in which the sliding parts are not then required.

In 1878, Mr. Abbott introduced his "combination" hive, in which the frames were placed, after the usual manner of Continental bee-keepers, parallel with the front of the hive, instead of at right angles to it. Although at this time almost* a novelty in England, this plan had been already justified by long experience. Many arguments were, however, adduced against it, to which Mr. Abbott replied as follows in the *British Bee Journal*, October, 1878: "We would plead that transverse frames are almost wholly used in many countries—Italy and Denmark, for instance—while the principle of causing bees to build transversely, where frames are not used, is 'as old as the hills,' and prevails throughout Egypt and Japan to the present day, and is, as a rule, a highly successful aid to obtaining large quantities of honey with the minimum of cost and labour." The bees are caused "to take possession of earthen tubes, similar to drain-pipes, of about 4ft. in length. One piece of comb having been fixed transversely, as a guide, a few inches from the entrance, parallel to this the bees build all their other combs, those for brood being at the front, and those for honey towards the rear end of the tube; and when harvest time comes, or the bees show signs of overcrowding, that end is opened by the removal of its plug, smoke is blown into it, and the bees thus driven towards the front, while the operator removes such combs as contain virgin honey." The plan of transverse combs is now largely adopted by British bee-keepers.

* See *British Bee Journal*, January, 1874, page 143, and March, 1874, page 170.

The general arrangement of the hive needs no special explanation. The brood frames (*bf*, Fig. 28) may be closed in behind by a tight-fitting dummy, and any number may be employed which the body is capable of accommodating, while but two only, in

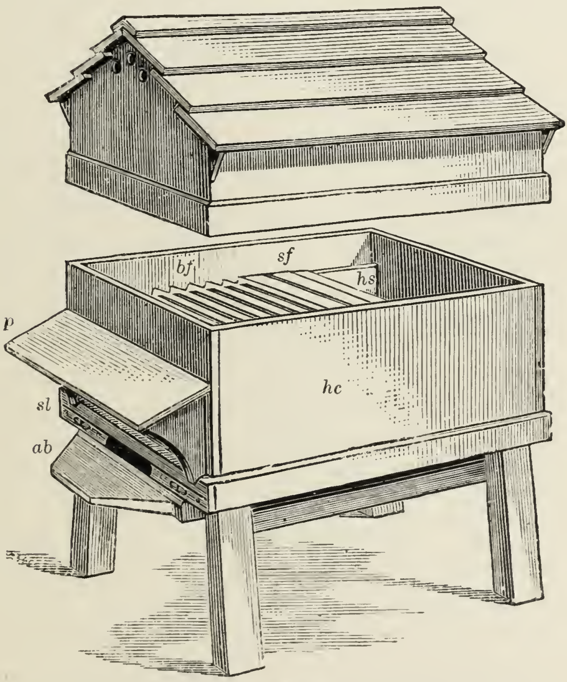


FIG. 28.—THE ABBOTT COMBINATION HIVE (Scale, $\frac{1}{12}$).
ab, Alighting-board; *sl*, Sliding Doors; *p*, Porch; *hs*, Hive Side; *hc* Hive Case; *bf*, Broad-shouldered Frames; *sf*, Section Frames.

virtue of the position of the frames, give no difficulty at all with regard to the entrance. Nor would frames running from front to back, if the door were placed at the angle (see pages 54 and 58), which I hold to be the only philosophical position.

When the bees, as spring advances, show signs of requiring increased space to store incoming honey, a division of zinc excluder (see Fig. 24) is introduced between the last brood comb and the last but one. Next to this are placed one or more wide frames (*sf*, Fig. 28), each containing sections similar to those used in supering, and beyond comes the before-mentioned division-board. The queen has thus no access to the surplus department, which, in consequence, cannot be spoiled by brood. The bees carry some of their pollen through the "excluder," which the one ordinary frame is left to receive, while the honey is stored alone in the sections the wide frames (*sf*) contain. What needs be said upon comb honey does not properly occur here; but, in reference to this arrangement, it must be immediately pointed out that, if brood has hatched, or is hatching, from the last frame, the comb honey will undoubtedly be sullied with particles from it, and these will mainly consist of larval excrement. A careful study of pages 21, 172, 181, 241, and 243, Vol. I., will make this clear. The bare idea of such a contamination is nauseating, and it *will* obtain, more or less, wherever comb honey is built on a *level* with the brood combs. Whether, apart from this consideration, the "combination" principle may be superior, equal, or inferior to that of storefying, must at present remain, it being sufficient to remark that progress, with solid reason, is most clearly leading us to confine the lower part of the hive, as absolutely as possible, to brood-raising.

Mr. Abbott pointed out that, by using excluder zinc

between the first and second frames from the entrance, the queen would be prevented from leading off a swarm; making the hive, in his own words, "*the only one in the world in which swarming can be positively prevented.*" The difficulty of removing dead drones may be urged, but is not of grave importance, if care be taken to inclose little or no drone comb, and the confinement be not long continued. Indeed, Mr. Jones

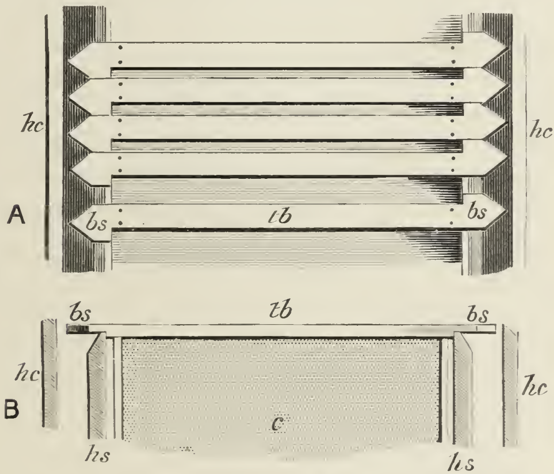


FIG. 29.—DETAILS OF ABBOTT'S COMBINATION HIVE (Scale, ⅛).
A, Top View of Frames—*hc*, *hc*, Hive Case; *tb*, Top Bar; *bs*, *bs*, Broad Shoulders.
B, Side View of Interior—*hs*, *hs*, Hive Sides; *c*, Comb, or Foundation; other Letters as before.

advocates a similar plan with the Jones-Heddon Hive, while Mr. Heddon less confidently suggests the same.

It will be remembered that all hives previously considered have had the ears of their frames wholly within them; but Mr. Abbott carries his top bar through, and so secures, as did Mr. Pettit before him, the advantage of handling without bringing the fingers into contact

with the bees. With Mr. Abbott's plan, the distance space is kept by the introduction of broad shoulders, which he at first placed on both sides of the ear. The giving of the whole interspace (as at *bs*, *bs*, Fig. 29) to opposite sides and ends of the top bar is an arrangement he derived from the Author. These broad shoulders have two advantages beyond the one stated: the fingers are not smeared with propolis, and the frame is steadily kept in position by the width of base the broad shoulders present; but the inconveniences and impediments to scientific working that their use involves are so great, that I have three times abandoned them, after making a serious effort at bringing them into use in my own apiary. Indeed, the temptation to adopt them vanishes with the introduction of the iron ear shown at Fig. 22. All the disadvantages of metal ends enumerated at page 66, except that relating to the imprisonment of the bees around the lugs, are with them intensified, while, in addition, the wood by turns swells and shrinks in most uncomfortable fashion. The propolisation adds grievously to the difficulty of management, and, without wedging between the ears, the interspace cannot be increased for wintering, for giving place temporarily to a thickened comb, or even to a queen-cage (now, with most of us, a small matter), while for extraction they are a serious drawback. Since the ears rest upon the hive side (*hs*, B, Fig. 29), thinned down to reduce the contact surface, the protection is least where it needs to be greatest. Chaff is recommended to be kept during winter between the hive case (*hc*) and hive side.

Hive-construction now seems to be passing into a new phase. Up to the present we have referred to two generically distinct frames only—the *standing* frame, or leaf, of Huber, and the *hanging* frame of Langstroth. To Huber the bee was of surpassing interest, in its anatomy, its instincts, and its architecture. His enthusiasm was that of the scientist, while honey and wax, that stimulate the perseverance of the professional bee-man, he almost left out of view. It is not unlikely, then, that although he failed to so modify his frame as to make it practical, it yet contained possibilities which he left unobserved; and the fact that so accomplished and honourable an apiarian as Mr. Quinby, after using the Langstroth for many years, abandoned it in favour of a species of standing frame, of which Huber's must be regarded as the antitype, obliges us to inquire into the reasons of his preference for the latter, especially when we call to mind that he had no trade interest to serve, and that he has been followed in his particular choice by some of the most successful and intelligent honey-producers of the American continent. Beyond this, although it is as yet impossible to determine the exact direction in which new developments may lead, it needs no gift of prophecy to see that the principle of inversion, which has already received a passing notice, will immediately modify our methods of manipulating comb honey, and that it will probably, in many apiaries, also extend to our body-boxes. If this be so, the hanging frame, which depends upon the force of gravity for keeping it in position, must either be rotated independently of that which supports it

(as at B, Fig. 22); or it will have to be substituted by one which either admits of being readily fixed, so that inversion of the hive shall not displace it (as in the Heddon, Fig. 34), or of standing equally well either way up, like the Hetherington-Quinby frame (*fr*, Fig. 31)—*i.e.*, in other words, be a species, of which the Huber standing frame is the generic type. In Quinby's adaptation of Huber's idea the ends are wide (*ws*, *ws*, A, Fig. 30), equalling the thickness of the comb and the interspace together, while the top and

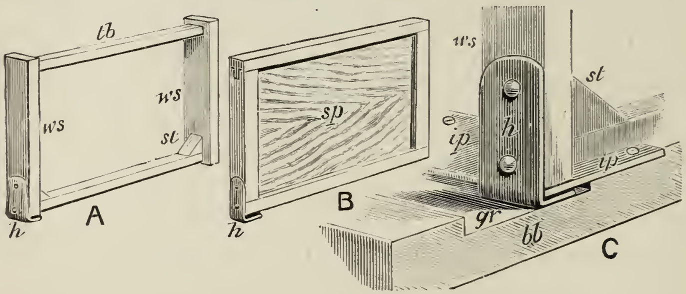


FIG. 30.—DETAILS OF QUINBY'S HIVE.

A, Quinby Frame (Scale, $\frac{1}{12}$)—*tb*, Top Bar; *ws*, *ws*, Wide Sides; *h*, Hook; *st*, Stiffening Piece. B, End Board (Scale, $\frac{1}{12}$)—*sp*, Sunk Panel; *h*, Hook. C, Corner of Frame, &c. (Scale, $\frac{1}{4}$)—*bb*, Bottom Board; *gr*, Groove; *ip*, *ip*, Iron Plate; *h*, Hook; *st*, Stiffening Piece; *ws*, Wide Side.

bottom bars are placed each $\frac{1}{4}$in. from the ends of the sides, and are only $\frac{7}{8}$in. wide. Thus, since neither top bars nor bottom bars meet when the frames are pressed up together, the contact-surface is reduced to one-half of that of the Huber frame, while the scraping up of bees on the floor-board is entirely prevented, by permitting to them passage-way beneath the bottom bar. Hives made of somewhat similar frames, placed side by side, were used by an Italian apiarian, from whom they have been often named

Giotto hives. Mr. Quinby stiffened his frames by angle-pieces (*st*), and saved them from the accident of falling over by grooving the bottom board (*gr*, C, Fig. 30) through its entire length, and fixing partly over this groove an iron plate (*ip*). To one corner of the frame he attached an L-shaped piece of iron hooping (*h*), so that, as one corner of the frame stood in the groove, slipping it forward brought the hook under the iron plate, and at once fixed it. To com-

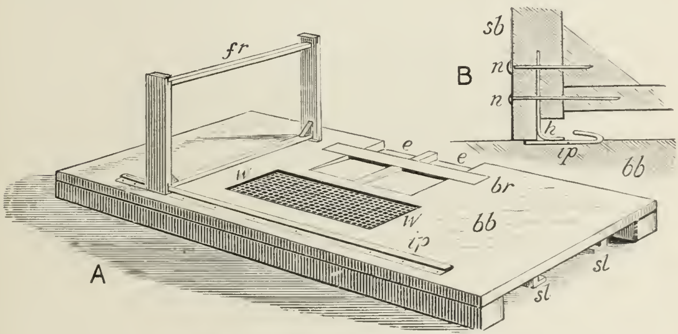


FIG. 31.—BOTTOM BOARD AND HETHERINGTON STANDING FRAME.

A, Bottom Board and Details (Scale, $\frac{1}{12}$)—*bb*, Bottom Board; *fr*, Frame; *ip*, Iron Plate; *w*, *w*, Wire Ventilator; *sl*, *sl*, Slide Runners; *br*, Bridge; *e*, *e*, Entrance. B, Section of Frame Corner (Scale, $\frac{1}{2}$)—*bb*, Bottom Board; *ip*, Iron Plate; *h*, Hook; *n*, *n*, Nails; *sb*, Side Bar.

plete the hive, end boards (B) were used having a panel recessed on one side $\frac{1}{4}$in., so that room was left for a thickened comb. On the other side, the end board had the panel flush with its frame. His entrance (*e*, *e*, Fig. 31) was ingenious; the bottom board, cut away in two parts, had running over it a thin iron bar, or bridge (*br*), made flush with the rest, and upon this the front corners of the frames rested. He also ventilated by means of a grating

of wire (*w*, *w*), under which a shutter ran in slides (*sl*, *sl*), to close the opening when not needed. The defect of the Quinby frame lay in the fact that the hook stood in a depression, instead of on a level with the bottom board. This has been remedied by the celebrated Hetherington Brothers. They place the surface of the iron plate (*ip*, B, Fig. 31) on the general level, and turn over one-third of its width. The side bar (*sb*) has a wide saw-cut made in it, 1in. deep, while the inner side is reduced in length ¼in.;

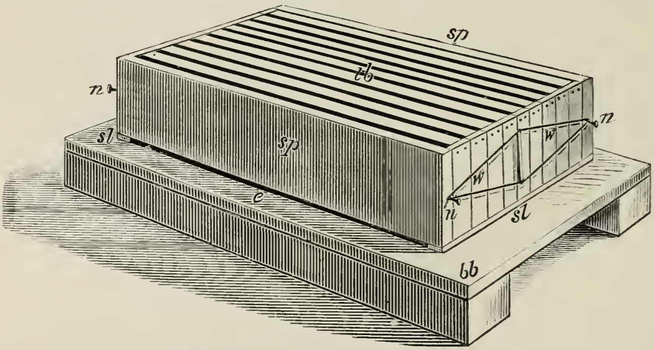


FIG. 32.—BINGHAM HIVE (Scale, $\frac{1}{12}$).

bb, Bottom Board; *e*, Entrance; *sl*, *sl*, Raising Slats; *sp*, *sp*, Side Pieces; *tb*, Top Bars; *n*, *n*, *n*, Nails; *w*, *w*, Wire Fixer.

the hook (*h*) is run into the saw-cut, and fixed by nails (*n*, *n*). As the frame is moved forwards, the hook passes under the bend of the iron plate, and fixes the frame as before; but this alteration permits of adding hooks at all four corners, so that the frames can stand either way up, or either end forwards. If the bees are to be examined, the hive can be opened at any desired spot; increase or decrease, division or union, even tiering up, can be performed with celerity.

For the latter purpose, however, the Bingham hive (Fig. 32) is most suitable. Here, as before, we have wide ends to the frames, but not a bottom bar. Slats are placed on the floor-board, to give the bees space beneath the three-sided frames (?), and form an entrance, which may be contracted by Langstroth blocks. The frames are closed by end boards (*sp*), carrying nails, around which wires (*w*, *w*) are placed. These are tightened, so that the hive is held together, by introducing a piece of wood, used as a spreader. With extreme simplicity of structure, great space is secured above, to receive surplus boxes, and as the frames are only 5¾in. deep, they can be doubled, reversed, or inverted in a body, as desired.

The Heddon hive has recently, in America, arrested such general attention that curiosity and interest have been excited in Europe. The opinions expressed regarding it have been instructively diverse; some have hailed it with extravagant anticipations of its capabilities, while others are disposed rather to condemn than approve. Since time has not yet permitted of putting it fully to the test, it is wise to be content with an account of its origin (for, in most of its features, it is not a novelty), with a statement of the objects of the inventor, and such a description that it shall be perfectly intelligible in every detail to those who have never seen it. Mr. Heddon at first endeavoured to couple the principle of inversion with the Langstroth or hanging frame, and to that end adopted a plan which I do not think at all equal to that suggested in Fig. 22. He practically removed from the old frame the bottom rail, and nearly half the lower part

of the sides, and then suspended a new and smaller frame within, by two screws passing through the centre of its sides, so that the comb could be swung round after the manner of a toilet-table glass. Thus, between the hive side and the lower part of the swinging frame, $\frac{3}{4}$in. intervened, of which he says: "There is no danger of the bees building combs, in even so large and handy a space, where such space is no higher up than shown in the illustration." My experience certainly does not confirm Mr. Heddon's. Bees, in my latitude, if crowded, would generally fill such a gap persistently.

Before inquiring into the reasons given by Mr. Heddon for desiring to invert combs at all, a few sentences should be devoted to the history of the question. The German* Hanoverian *Central-blatt* of September 1st, 1874, speaks thus of inversion: "The masterpiece of bee-keepers in *Gatinais* is to have very strong and populous hives as early as the honey glut takes place. When the *Onobrychis sativa* (Sainfoin) flowers, they turn their hives (straw skeps) upside down, so that the crown stands upon the floor-board, the open part uppermost. Upon this they place perforated sheet-iron (No. 35), and upon that a second hive, already partly built up with empty comb. . . . The holes of the sheet-iron allow only worker bees to pass; it is, therefore, evident that the bees soon fill, with extra fine honey, the upper hive, which has already clean, new comb in it."

Mr. Desborough, of Stamford, adopted this method, with the result that the honey contained in the in-

* See *British Bee Journal*, March, 1876, page 210.

verted combs was carried up into the super. To explain this, the theory* was advanced that, as the cells have an inclination (G, Fig. 36, Vol. I.) upwards, they are unable to retain their honey, and the bees cannot possibly fill them when the comb is inverted; and that, if all the cells are at the same time brought into this condition, the bees must, *nolens volens,* carry the honey aloft into the super then presented to their attention.

Mr. Heddon's† opinions, like my own, do not accord with this notion. His views may be thus summarised: Bees, especially Italians, in frames of the usual depth, persist in crowding the queen, by storing that honey that ought to go into the surplus department along the upper part of the brood comb, and further down in the corners (see Fig. 7).

If a comb so filled be reversed, the honey is placed in an *unusual position—that normally occupied with brood;* should this be done *in the breeding season*, or whenever the bees are intent upon increasing their numbers, the honey will be immediately removed to the surplus department, and soon the comb will be one solid sheet of developing bees—a glad sight to those whose experience has taught them the value of a compact brood-nest, free from honey.

A question which may appear trivial to the unobservant, but which is, after all, of the deepest moment, here presents itself: Does the truth lie with Mr. Heddon, or with the theory of the *British Bee Journal* of 1876? To my mind, the latter clearly has nothing

* See *British Bee Journal*, February, 1876, page 184.

† "Success in Bee Culture" (page 86), by James Heddon.

to support it. I proved many years ago that comb could be stored, on both sides,* with honey, even if it stood at a very considerable angle, in which some of the cells were more nearly perpendicular than horizontal. The manner of filling-in store, as explained at page 174, Vol. I., shows this to be possible. Capping, added at the lower margin, is made to grow upwards and around as honey is added, until the finally-placed wax shred closes all in.

If the dip of the cell caused the desired removal, it would do so at any time while honey is being gathered or syrup-food taken, and the effect need not be limited to periods of rapid breeding, as Mr. Heddon states, and as my own experiments have fully shown it must be. *It is the unnatural position of the honey, as beneath the brood*, which acts mainly in causing its removal above; and this being so, we learn at once, that a horizontal division of the brood-nest, made to consist of two shallow body-boxes, rather than one deep one, enables us so to manipulate *without* inversion that this desired effect may be obtained. We have only to interchange the lower with the upper—*i.e.*, to carry the honey down and the brood up, as can be at once accomplished in the Carr-Stewarton or the Bingham. But it logically follows from what has been already said, that, even with inversion, the honey will only be transferred to the normal bottom corners of the comb, unless these have already become occupied with brood.

* Mr. Corneil, of Ontario, has informed me, since the above was written, that he placed a comb of store *flat* over a stock to feed it, and that, after the removal of the honey, the queen laid in the cells of the under side, and, as the brood hatched out, storing and sealing followed.

There are some advantages claimed for inversion which interchangeability alone will not give, and which had better be examined after the Heddon hive has become familiar.

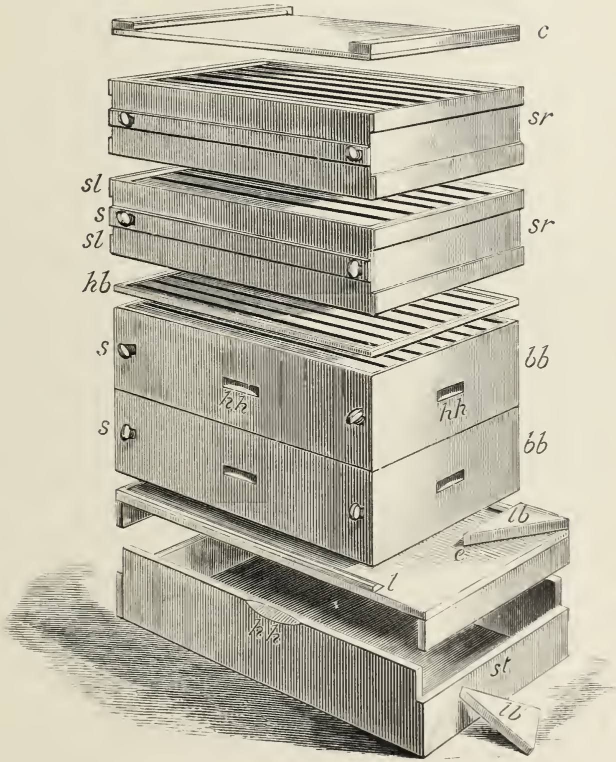


FIG. 33.—THE HEDDON HIVE (Scale, $\frac{1}{12}$).

st, Stand; *bb*, *bb*, Body or Breeding-boxes; *hb*, Honey-board; *sr*, *sr*, Section Racks; *c*, Cover; *hh*, *hh*, Hand Holds; *lb*, *lb'*, Langstroth Blocks; *e*, Entrance; *l*, Lath, or Cleat, giving Bee-space; *s*, *s*, Screws; *sl*, *sl*, Strengthening Slats.

Although we are discussing this question in the light of principles whose application is universal, it

will be better that I should give the exact measurements of the Heddon, premising simply that these are absolutely empirical. The body-boxes (*bb*) are each $5\frac{3}{4}$in. deep by $19\frac{7}{8}$in. by 13in. outside, the ends $\frac{7}{8}$in. and the sides $\frac{3}{4}$in. thick. Before nailing together, the inner part of the top and bottom edges is rabbeted down (*r* and *r′*, Fig. 34) $\frac{3}{16}$in., leaving a rim $\frac{3}{8}$in. wide only, so that, when the boxes come together, they touch only at the $\frac{3}{8}$in. rim, while the $\frac{3}{16}$in. rabbet in each make together a full bee-space (*bs*)

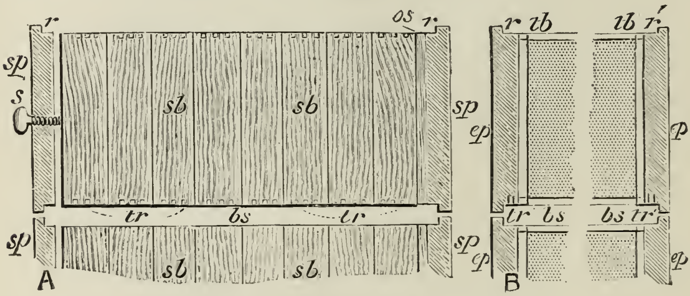


Fig. 34.—Heddon Hive Details (Scale, $\frac{1}{12}$).

A, Ends of Frames, driven together by screw seen by removal of Hive End—*sp*, Side-piece; *s*, Screw; *sb*, *sb*, Side Bars of Frames; *r*, *r*, Rabbets; *os*, Offset; *bs*, Bee-space; *tr*, Tin Rest. B, Longitudinal Section of Hive, showing Combs or Foundation on Frames—*tb*, *tb*, Top Bar; *ep*, *ep*, End Pieces; other Letters as before.

of $\frac{3}{8}$in. This principle of allowing a half bee-space above and below, in each horizontal section of the hive, so that the needed $\frac{3}{8}$in., and no more, is given in any possible combination, is a salient and new feature in the Heddon. The bottom board carries a lath (*l*, Fig. 33), $\frac{3}{8}$in. deep, and $\frac{3}{8}$in. wide at its upper edge, upon which the hive rests, so that a larger, but not excessive, bee-space is made beneath. An entrance (*e*) is thus secured, which is regulated by the Langstroth blocks (*lb*, *lb′*). Since the body-boxes are

made invertible, Mr. Heddon has felt himself compelled to abandon the hanging Langstroth frame, and adopt a modification of the standing form of Quinby, with wide ends. This frame he dovetails together, in the manner of section-boxes. The top and bottom bars are $\frac{1}{4}$in. by $\frac{13}{16}$in. by $18\frac{1}{16}$in., while the end pieces are $\frac{3}{8}$in. by $1\frac{3}{8}$in. by $5\frac{3}{8}$in.—*i.e.* (to preserve the before-mentioned bee-space), $\frac{3}{8}$in. shallower than the body-box itself, within which the length of the frame has $\frac{1}{16}$in. play. It will be seen that the end pieces of these frames are $\frac{9}{16}$in. wider than the top and bottom bars; hence, the space between any two top bars, or bottom bars, will always be $\frac{9}{16}$in., by which the bees pass freely from section to section of the hive body. To prevent these frames falling through the body-box, the inside measure of which is $\frac{1}{16}$in. greater than their external length, strips of tin (*tr'*, *tr'*, B, Fig. 34) are nailed on to the lower rabbets of the end pieces (*ep*, *ep*). These tin strips project $\frac{1}{8}$in., and give a resting-place for the frames which stand upon them. As the outside width of the body-box is 13in., and the thickness of the sides (*sp*, *sp*) $\frac{3}{4}$in., $11\frac{1}{2}$in. intervenes between the latter. Eight of the frames, each $1\frac{3}{8}$in. wide, occupy 11in. of this, so that the $\frac{1}{2}$in. play provides the additional space required on the outside of the outer combs. To divide this equally, a narrow offset (*os*, A), $\frac{1}{4}$in. thick, is nailed into the corner, on to the side (*sp*); against this the outside frame rests. Wooden thumbscrews (*s*, *s*, Figs. 33 and 34), that have been previously boiled in tallow, are now tapped into the sides, so that their ends work on the edges of the wide sides of the

frames, squeezing them together until they hold their position securely when the body-box is inverted.

The stand (*st*, Fig. 33) needs little explanation. The cleats of the bottom board touch its end pieces a trifle before the bottom board itself touches the side pieces, such a bearing causing the weight of the hive to assist the cleats in keeping the bottom board perfectly straight.

The honey-board (*hb*) Mr. Heddon arranges on the "break-joint" principle—its slats standing over the interspaces between the frames of the body-box—with the object of preventing the building of brace combs, as they are termed—*i.e.*, strips and irregular extensions

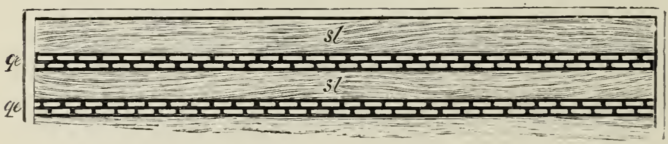


FIG. 35.—PART OF QUEEN-EXCLUDING HONEY-BOARD (Scale, $\frac{1}{6}$).
sl, *sl*, Slats; *qe*, *qe*, Queen-excluder Zinc.

of comb, introduced between upper and lower frames, or frames and section-boxes, filling the bee-space, and attaching together, according to bee notions of security, parts that the bee-keeper desires to remain separate.

The frame which holds the honey-board together extends in thickness $\frac{3}{16}$in. both above and below the slats, thus keeping the half bee-space so characteristic of the Heddon system. The honey-board, as supplied, has no further addition, but the inventor recommends, and Mr. Jones actually places, queen-excluder zinc (*qe*, Fig. 35) between the slats, which have saw kerfs

made in their edges, so that zinc wider than their inter-space can be run in, and kept in position. Zinc expands and contracts greatly by change of temperature, and would be, consequently, likely to seriously buckle if given in full sheet; but this is entirely prevented by the arrangement described.

The section-racks (*sr*, Fig. 33) are constructed on the general plan of the brood-chambers, with which they have the same length, but a slightly greater breadth; their edges, however, abut accurately upon the brood-boxes, which is accomplished by giving to the sides a small outside bevel. Since they are intended to hold frames accommodating $4\frac{1}{4}$in. by $4\frac{1}{4}$in. section-boxes, they are only $5\frac{1}{8}$in. deep, which allows $\frac{1}{2}$in. for top and bottom bars of frames, and $\frac{3}{8}$in. for two half bee-spaces. The sides of the section-racks are $\frac{5}{8}$in. only ($\frac{1}{8}$in. less than that of the brood-boxes), giving 1ft. full of internal width to the section-rack, which thus accommodates seven frames, each carrying four of the sections previously named. The thinning of the side necessitates battening, to give the tightening-screws (*s*) sufficient hold, and the rack itself adequate rigidity. The tin rest and rabbet are applied to these racks as to the body-boxes. The arrangement and management of surplus honey receptacles will be treated generally in a later chapter, to which any further description may well be deferred, especially as other inventors have here continued the march beyond Mr. Heddon's position.

Mr. D. A. Jones, while retaining the specialties of the hive under consideration, has introduced several

modifications, which will be generally accepted as improvements; *e.g.*, while his section-rack is equally suitable to two distinct sizes of sections, he has made the whole of the outer cases, whether for breeding or honey, in all respects alike, and completely convertible.

These all have external battens, which act as hand-holds, and give to the slight $\frac{3}{8}$in. thick cases the stiffness they lack. The latter are $15\frac{1}{2}$in. by $14\frac{1}{2}$in. outside, and $5\frac{1}{4}$in. deep. The eleven frames to carry the brood-combs have broad ends, which are only $1\frac{6}{20}$in. in width. They, together with the extra space required for the outside combs, occupy the $14\frac{3}{4}$in. between the ends of the box. Frames to carry sections are made to run both from side to side and from front to back; each of the former takes three sections $4\frac{1}{4}$in. by $4\frac{1}{4}$in., the latter four sections $3\frac{1}{2}$in. by $4\frac{1}{4}$in., both these sizes being regarded, in Canada, as standards.

We have now before us these hives, which are practically one, and it remains to inquire what advantages they possess as a whole, or in their parts, and to seize upon any points, should such be found, which may be beneficially introduced into our methods of hive-construction. First, every British bee-keeper of experience must feel that Mr. Heddon's method of solving the mechanical difficulty of making his body boxes invertible, by abandoning the Langstroth frame and substituting for it the wide-ended standing one, cannot be regarded as final; and, indeed, Mr. Heddon himself refers to it in language which is manifestly apologetic. He says: "Although these are fixed frames, they are readily removed, and by simply

loosening the screws. I will endeavour to explain how we overcome the usual difficulties accompanying such frames. By virtue of the exceeding shallowness of our frames, and the use of comb foundation, we procure combs almost perfectly straight. The greatest trouble usually arises from uneven combs—combs irregular at their tops, just above the cells occupied with brood. This occurs mainly from the fact that, where bees use combs for storing, they leave only about $\frac{1}{4}$in. space between them, while those used for brood are about twice that distance apart. These shallow frames, and the practice of inverting and interchanging the cases containing them, give us straight, uniform combs throughout, and completely filled with brood, nearly all the time we manipulate them." In criticising these close-ended frames, which are ten times more difficult of management if placed, as we here have them, in an external case, instead of in the manner adopted by Hetherington or Bingham, we must, to be fair, remember that the idea is "to manipulate hives, not frames," and that almost every required operation can, it is held, be performed without the removal of the latter; but, giving these considerations their fullest weight, it must still be admitted that Mr. Broughton Carr but expressed what almost all British bee-keepers would endorse, when he says :* "In our apiary, the whole affair, frames and screws, would become fixed and immovable with propolis, damp, &c., in a single season. We have always had an insuperable objection to close-ended frames, on account of the bee-crushing and propolisation they

* *Bee-keepers' Record*, December, 1886, page 214.

cause—he who says they don't, errs; but here the mischief is considerably increased by the two ledges on which the frames rest." In addition to Mr. Carr's stricture, may it not be added, that the difficulty of manipulating the broad-ended brood-frames is even exceeded in the Heddon arrangement of the section-boxes? These, as already explained, are pushed into frames, to be, of course, stained by propolisation around the four sides, on both faces, which would make their removal so awkward that cracking of the sealing would be a most likely accident.

Besides, the tightening screw, especially if used throughout the year, as applied to brood-boxes has many objections. If brought up so as to prevent the sinking of combs at the time of inversion, swelling of the wood would tend, with almost irresistible force, to drive the hive side from its place; while shrinking would permit the frames to drop, and close absolutely the entrance, to the destruction of the colony—a difficulty which has been already encountered in a less changeable climate than our own. Mr. D. S. Hall, writing to the Canadian *Bee Journal*, utters his complaint respecting this very matter, and suggests, instead of tightening-screws, iron rods, passing all the frame ends in the thickness of the hive side, and having a bent portion to grasp the last frame behind it. On the near end of the rod, which is external to the hive, he would place a thick indiarubber washer, to give, by its elasticity, a certain play for swelling or shrinking, and upon this washer a screw nut. It is, however, needless to dwell longer on the unsuitability of the Heddon frame, for two reasons: First, that further

examination will, I believe, show that the plan of interchanging body-boxes, as stated at page 94, together with anti-swarming devices, presently to be introduced, will give us even more than inversion of the brood-nest can accomplish; and, second, it is certain that the inventiveness of bee-keepers will quickly devise a really workable method of making stock-boxes invertible. Indeed, Mr. J. M. Hooker has

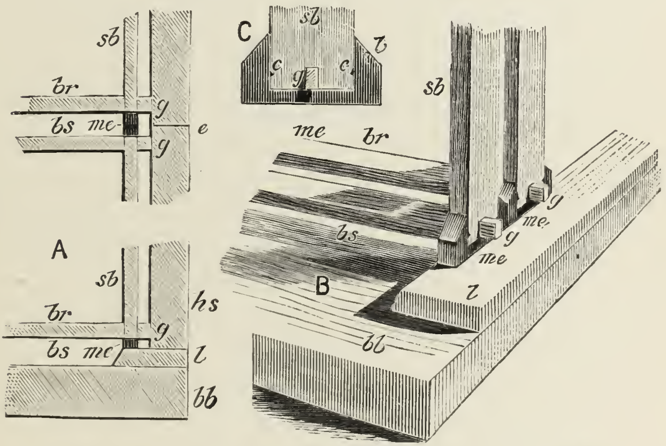


FIG. 36.—THE HOOKER SYSTEM OF INVERTIBLE HIVE SECTIONS.

A, Part Section of Frames, &c. (Scale, ¼)—*bb*, Bottom Board; *l*, Lath on Bottom Board; *bs*, *bs*, Bee-space; *me*, *me*, Metal End; *g*, *g*, Guide; *br*, *br*, Bottom Rail; *sb*, *sb*, Side Bar; *hs*, Hive Side; *e*, Edge of Hive Section. B, Perspective View of Part of Two Frames in Position—Letterings as before. C, End View (Scale, ½)—*c*, *c*, Cutting Edge; *b*, Bevelled Face; other Letterings as before.

already ingeniously satisfied the problem, in a manner which leaves Mr. Heddon quite in the rear, so far, at least, as British bee-keepers are concerned, for here climatic conditions seriously handicap any arrangement which would be disorganised by constantly-recurring periods of dampness. Mr. Hooker retains the ⅞in. wide frame, all sides of which are made of

$\frac{1}{4}$in. stuff. Upon each corner he places a special form of metal end (*me*, Fig. 36), which extends the half bee-space above the top or below the bottom, rail. The frames run parallel with the hive entrance. The objectionable tin rest of Heddon is rendered entirely unnecessary by widening the lath (*l*) on the bottom board, so that it not only supports the hive side (*hs*), but also the metal end; by which device the bottom rail (*br*) is raised a full bee-space from the bottom board. At each end of the top and bottom rails of the frames a central tongue (*g*) is left. This runs through the side bar, and extends $\frac{1}{4}$in. beyond it, so that the frame is prevented from touching the hive side while it is being inserted; and at all times the accurate lateral bee-space is preserved. The width of the metal end spaces the frames; and, when they are placed in position, a dummy with a stiffening-piece is operated upon by an outside screw, which so pushes the perpendicular, external faces of the metal additions together that, as Mr. Hooker informs me, the most heavily-laden frames can be inverted bodily, in the hive section, without the smallest risk. Mr. Heddon's hive sections, although intended for inversion, yet are upright when the frames rest on the tin strip, and upside down when in the inverse position; and then they somewhat dangerously—as has been already pointed out—depend exclusively upon the retaining power of the screws for preventing the frames slipping. Mr. Hooker's hive sections, however, are absolutely alike above and below, so that the expressions "upright" and "upside down" do not apply to them. In no position do the

frames depend on the screw, but rest always on the lath (*l*) or on the metal ends of a lower hive section. This not only dispenses with the possibility of frames sinking, but permits of the screw being slackened, and the frames manipulated, whichever side of the hive section may happen to be upwards.

Again, as the top and bottom edges of each hive section are exactly in the plane of the respective top and bottom faces of the metal ends, when one hive section is placed on the other in storifying, their edges abut simultaneously with the metal ends, which are thus solidly supported, however far the tiering may be carried; while, of course, the bee-space is secured. The section-cases are similarly arranged, but this is not the correct place to describe them. The metal ends have, cast upon their proximate faces, cutting edges (*c*, *c*, C), which carve grooves into the side bars as they are driven on, and so hold them with sufficient firmness. Since the frames—as previously pointed out—would not drop, even if the screw utterly failed, it is possible that hard-wood side bars to the frames, having their end shoulders cut to the distance desired for comb and interspace, might answer well for brood-boxes. In combs intended for extraction, the fixed shoulders would be an impediment. The bevelled form (*b*, C) given to the metal end is obviously to permit of the frames slipping past each other, without hanging, while they are being manipulated.

It would be both unphilosophical and unfair thus to dismiss the Heddon without noting that it has called our attention to some points of great moment, and

that it has also, interwoven with old plans, novel methods which will hereafter make their mark. It is narrowness, not patriotism, that would deny to one of another country his full meed of praise, and I conceive that the unprejudiced will not dispute that the half bee-space in each hive section and in the bottom board; the narrow, abutting edges, giving possibility of rapid handling; and the general invertibility of the whole, although associated, perhaps, with some crudities, yet mark another hill-top passed in the progressive march of practical apiculture. Mr. Heddon and Mr. Jones have also, by their hives, brought prominently before us, and have done not a little to settle, a question which has been much discussed—viz., the most desirable interspace to allow between brood-combs. Mr. Heddon makes his frame end $1\frac{3}{8}$in., while Mr. Jones allows $1\frac{1}{4}$in. full, or, more accurately, $1\frac{6}{20}$in., a plan which resulted, apparently somewhat to his own surprise, in the building of worker-cells, to the exclusion of drone-cells, narrow strips of foundation only having been given. A little attention to the arithmetic of the matter will elucidate the reason of this. Worker-comb, within a very small fraction, is $\frac{15}{16}$in. in cross-section. Bees, each requiring $\frac{5}{32}$in. for the accommodation of its bodily presence, need to perambulate both faces of this comb, to generate heat, to brood the eggs, and to carry food to the helpless larvæ. The whole structure, with its two layers of attendants, thus equals $\frac{15}{16}$in. + $\frac{5}{16}$in. = $\frac{20}{16}$in., or $1\frac{1}{4}$in. Should starters be given $1\frac{6}{20}$in. apart—*i.e.*, $\frac{1}{20}$in. more than the necessary $1\frac{1}{4}$in.—the bees have just elbow-room, and no

more. It is their practice, in a state of nature, to place their combs about $1\frac{9}{20}$in. or $1\frac{10}{20}$in. from centre to centre. Such wide spacing is adopted in order that they may have liberty, according to their habit, to break into drone-cell making at any spot, as the comb is worked downwards; for their drone-comb, if used for breeding, is, when capped, as nearly as possible $1\frac{6}{20}$in. in thickness. The bee-keeper, however, by settling the interspace for the little artificers at $1\frac{6}{20}$in., while permitting, as we have seen, all needful room for worker-comb, bars drone completely, because its capped cells extend from the midrib $\frac{13}{20}$in., or $\frac{104}{160}$in. The worker-comb opposite to it extends, in like manner, from its midrib $\frac{15}{32}$in., or $\frac{75}{160}$in.; the two together thus occupy $\frac{179}{160}$in., which, subtracted from $1\frac{6}{20}$in., the allowed distance from midrib to midrib, gives $\frac{29}{160}$in. only, or insufficient room for the queen to pass. The worker-comb would thus be useless for the raising of brood. When greatly cramped, in order to get room for queen-cells bees will cut down worker-comb; but it is not their practice so to do in order to raise drones, and hence drone cells under these conditions would only very occasionally be produced.

Combs will only be built satisfactorily, from starters gauged so closely, when bees are crowded in in sufficient numbers to work all the combs down simultaneously. Care on this point will generally secure most regular and beautiful work. The calculation just given, though, possibly, tedious, needs no apology for its introduction, and should be regarded as supplementing the statements made at page 72. These

considerations seem also to show that all metal ends have been made too long. Would not $1\frac{6}{20}$in. be better than $1\frac{9}{20}$in.? If thus reduced, some of the objections to them would be lessened; and they might, by chips of section-box placed between, be easily made to bring up the interspace to the size desirable for storing or wintering.

It was remarked on page 95, that some advantages are claimed for inversion which interchanging alone will not give. These claims deserve attention. First: Bees do not build their combs down to the bottom rail, nor to the lower part of the sides of the frame, while they round off the corners as seen in Figs. 7, 18, and 27; but, if the frame be inverted, the instinct which impels them to keep the combs securely attached above causes them at once to add cells upwards, and at the sides, until every part of the frame is fully filled. This absolute filling of the frame is no slight improvement. It gives increased brood accommodation in the same general area; it solidifies the setting of the comb, so that in handling, in extraction, or in the shaking of a journey to the heather, *e.g.*, it is less likely to suffer; it excludes the possibility of adding slyly-packed drone-cells, which may enable queens of an undesirable strain to perpetuate themselves; it makes the work of brushing or shaking bees from the combs more simple and rapid; and it prevents queens from eluding us by hiding between the comb and bottom bar, as they not infrequently do. To secure these advantages, but one inversion in the whole history of the comb is required; and they may be secured, with frames of the usual form, by

simply cutting out its comb with care, and placing its top edge upon the bottom rail. Temporarily securing against displacement, as in "Transferring" (which see), and returning to the bees to complete the work, are all that is needed. Should the comb not be heavy with honey above, its bottom edge may be made true, and it may be replaced in its normal position, if desired; but inversion is generally to be preferred. Second: It has been stated that inversion is a certain means of preventing swarming, because it destroys the larvæ in the queen cells. It is sufficient, at present, to remark that this is only partially true, and that dependence upon mere inversion for swarm-prevention is delusive.

The objection that inverting old and dirty combs immediately beneath sections leads to staining of the comb-honey—of which I have examples in my possession, through the kindness of Mr. Corneil—may be reserved until treating of "Sections."

A hive much resembling, in general arrangement, the one used by Mr. W. Raitt, and with which he has been long so successful, has been designed by Mr. John Howard, and called by him the "Holme Wood," in which are shown so much ingenuity and apicultural knowledge that this chapter, though already lengthy, could not be well closed without introducing it. Mr. Howard has, upon the old storifying system, engrafted modern, and some original, contrivances, which make his hive an excellent one for the honey-producer. He does not covet inversion for his brood-boxes, while it may be applied or not to the section-crates, as the bee-keeper may desire.

A substantial stand (*st*, Fig. 37), with short legs, is capable of carrying any number of hive sections the

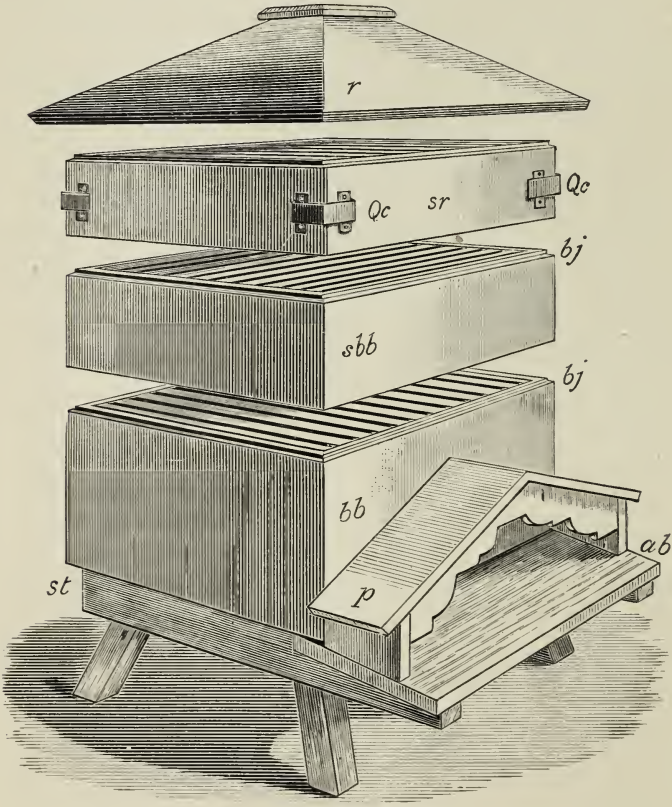


FIG. 37.—HOWARD'S "HOLME WOOD" HIVE (Scale, $\frac{1}{8}$).

st, Stand; *ab*, Alighting-board; *p*, Porch; *bb*, Body-box; *sbb*, Shallow Body-box; *sr*, Section-rack; *r*, Roof; *Qc*, *Qc*, Quinby Clips; *bj*, *bj*, Break-joint.

tiering system can by any possibility require. The bottom board is so contrived that, when the body-box

is pushed fully forward, the entrance runs the whole width of the hive. Drawing the latter back reduces the opening to one of 2in., formed by cutting a hollow of that width into the floor-board itself. A porch (*p*) may be provided as desired; but as this is not fixed to the hive front, no interchange of parts interferes with its position. Cheshire slide-doors, to regulate the entrance, usually accompany it.

The body-boxes are made of two sizes, one (*bb*) accommodating Standard frames, the other (*sbb*) only 5½in. in depth. They are both square in plan, so that every storey added may have its frames crossing those below it, as in the Figure, in order to miminise brace-comb building. The frames, which are, in fact, Mr. Simmins's, are 1in. wide, and have the ¾in. thick top bar only 15½in. or 16in. long: long enough for all practical purposes, for it cannot be doubted that the 17in. top bar of the Standard frame is not only excessive, but that it has been a great impediment to hive improvement. The usual ⅜in. lug is left by cutting the top to a shoulder (*sh*, Fig. 38), against which the ¼in. thick side bars (*sb*) are nailed. The frame is very solid, but of course more costly than those commonly used. All the hive sections fit water-tight, one upon the other, without filleting, by means of a slightly broken joint (*bj*, *bj*, Fig. 37, and A, Fig. 38). The ⅞in. side receives a ½in. rabbet, which is carried down ⅛in. The bevel (*be*) put on the outer half of the top edge of each hive section throws off water, and is thought by Mr. Howard to give that security against in-driven rain which the Heddon lacks.

Two wide or three shallow body-boxes may be

used, or the wide and shallow together. The shallow frames have no bottom rail, and it is claimed that these give complete interchangeability "*upon natural lines*," and preserve winter passages by the division of combs into two. The writer would, however, prefer to winter his colonies in one rather than two of the body-boxes. It is directed that these shallow bodies, when used as a brood-nest, should have their combs $1\frac{1}{4}$in. only from centre to centre. A shallow body-box, when comb-building is rapidly progressing above, may be added beneath as a swarm-preventing eke; and should the bees then furnish it with combs, these may be utilised for storage, or employed in sections, according to plans which Mr. Simmins has originated.

The sides are fitted together by halving out, and are for the section-racks (*sr*) held in position by Quinby clips (*Qc*, *Qc*, Fig. 37), each consisting of two iron plates screwed to the hive, and an angle piece which grasps both, but which can at once be removed by a few upward taps with the hammer, when the sides fall apart to admit of ready cleaning. This plan has advantages, especially to those but little acquainted with mechanical matters, and who, nevertheless, would prefer to buy their hives in the flat. The section-racks are only the depth of the sections themselves, which, in consequence, stand flush with the top and bottom edges of the rack containing them; and as the frames also stand flush with the body-boxes, the needful bee-space is provided by wooden rings, or, as Mr. Howard calls them, "loose trays," having the break-joint on their upper and lower faces. One of these is added beneath each

section rack, in which the sections are securely held by an iron thumbscrew. If inversion be the practice, the rack is rotated independently of the bee-space ring. Should the bee-keeper find inversion of no assistance in securing well-finished sections, he may nail one of the spacing-frames on each of his racks, when the latter assume a well-known form, and he proceeds "as of yore."

The roof (*r*) is a very old acquaintance, but one to which has been ascribed the virtue of not blowing off. The reason is quite apparent. When a current strikes the hive side, the air is reflected upwards from the roof, and, by the law of reaction, the roof is held down. I have seen these covers stand in a gale of wind without moving, but it is wisest to load them, since gusts shooting upwards *may* cause their displacement, and work mischief. For this purpose, one or two bricks may be battened in beneath the top square of wood.

The most strikingly novel plan about this hive is that which distances the frames, and keeps the queen in her proper quarters, at one and the same time. Mr. Howard turns up zinc strips (as at B, Fig. 38), making each the length of the top bar, the width of the desired interspace, and with perpendicular sides of $\frac{3}{8}$in. The ends are plugged with wood blocks (*wb*, B, Fig. 38) as far as the inner wall of the hive, and the upper sides are perforated with holes 1in. long and queen-excluder width. The frames are now brought into position, as at C, with one of these queen-excluder strips between each; a honey-board (offering but very little impediment to the bees) and a distance-keeper

are provided at one and the same time, and that without increasing the height of the hive, while this form secures the considerable advantage of being applicable to any less number of frames than the hive body carries. The ear of the frame is covered on all sides, and so propolisation is there impossible, although

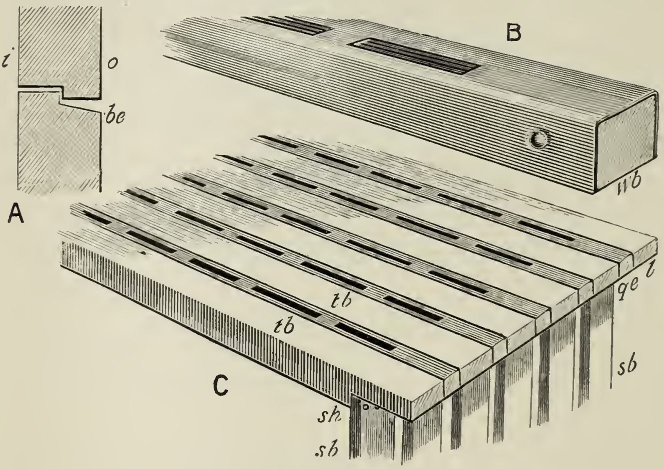


FIG. 38.—DETAILS OF "HOLME WOOD" HIVE.

A, Break Joint (Scale, ½)—*i*, Inside; *o*, Outside of Hive; *be*, Bevelled Edge. B, Zinc Queen-excluder and Spacer—*wb*, Wood Block. C, Zinc Excluding Strips as used (Scale, ¼)—*tb*, *tb*, Top Bars; *sh*, Shoulder; *sb*, *sb*, Side Bars; *qe*, Queen-excluder; *l*, Lug.

it would probably be rather excessive about the zinc standing over the comb.

Other interesting points in this hive will occupy us in their appropriate places.

The remark—the like of which is often made—that shallow body-boxes permit of interchanging "*on natural lines*" calls for some comment. I quite disagree with the implied statement that "interchanging"

is in itself one whit more natural than "inversion"; for it is through the unnaturalness (see page 94) of both that they achieve results which are unnaturally favourable to the bee-keepers. Many of the latter appear to me, in their objection to that which is artificial, to overlook the fact that nearly all management is necessarily of this nature. What, *e.g.*, can be more unnatural than supering? and yet upon that very fact its success depends. Bees build normally from the roof of their domicile, storing their honey above and breeding below. We practically uplift their roof, and present them with a hateful gap, which they—circumstances permitting—struggle to fill to our advantage. What more unnatural than a fowlhouse or a cow-shed? Yet the farmer knows that, without these "artificial" additions to his farm, his poultry would die, and his stock suffer. How ludicrously artificial is dredging up the immotile oyster, carrying it to another climate, and replacing it in a new pasture! Yet the gourmand knows that the high condition of the mollusc he so much loves is due to its change of residence. Every method of management must stand or fall by results, and cannot be logically prejudiced, much less dismissed as incorrect, simply upon the ground that it is unnatural.

It is a great advantage to the bee-keeper to be able, at least for a season or two, to watch bees actually at work. Observatory or unicomb hives, as they are called, give this opportunity, and are a never-failing source of delight to visitors to the apiary. They consist most usually of a narrow (see page 43) box, capable of accommodating, in a single layer, four or six frames. One side is made into doors (see Fig. 39), and the bees are

confined, and to some extent protected, by double glass. If the hive be placed in a room (its most suitable position), a long tunnel must be necessarily traversed by the bees in leaving and returning. This may be very much extended, and yet, in a few days, will present no impediment to the labourers. Our conventional hive entrance may be widely departed from without bad effect. I have seen, *e.g.*, in Mr. Simmins's

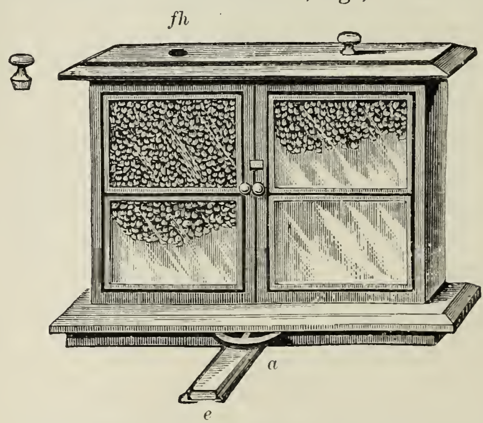


FIG. 39.—NEIGHBOUR'S OBSERVATORY HIVE (Scale, $\frac{1}{20}$).
fh, Feedhole; *e*, Entrance; *a*, Axis of Rotation.

apiary, bees travelling up and down a long, perpendicular shaft, which left their hive at one of the top corners, and then turned abruptly at a right angle to conduct them through a thin wall into the open. Not only did the workers know their way about, but the queens flew from this and similarly situated stocks, mated, and returned in the most orderly manner. It is usual to people unicomb hives by transferring combs and adherent bees from an established stock, giving no more brood than can be cared for under the new and

unfavourable conditions. Baize-lined doors cover the glass ones, while a warm, movable shutter, is added on the opposite side, greatly aiding the bees in maintaining temperature. In two cases, bees so situated have, in my experience, survived the winter; but the better course is to add the stock to a weak one in the autumn. Should the hive be exposed to the direct rays of the sun, the glass will permit the radiant heat to enter, but will prevent its escape, and, in consequence, temperature will rise rapidly, until combs melt and the stock is wrecked. Low powers of the microscope can be used in examining the eggs and growing larvæ. For this purpose, artificial light should be thrown, as directly as possible, into the cells, by a bull's-eye condenser. Mr. Abbott introduced perhaps the most convenient, and, in my opinion, the most generally useful, form of observatory. Instead of occupying a table, and engrossing a considerable space, it is held at the top and bottom corners by pivots which are attached to the wall, so that it moves after the manner of a door. The lower pivot is large and hollow, the exit and entrance passing through it. It may be placed by the side of the window, and rotated into the light for examination, or pressed back to the wall out of the way. Much ingenuity has been expended in devising unicomb hives which could be folded up into a compact form, so that the heat of the bees might be retained easily, but no "observatory" presents so few disadvantages as the more simple arrangements described.

Having now introduced and discussed with some fulness almost every principle of hive-construction

which promises, or did promise in a recent past, to assist the intelligent apiarian, it remains but to give some directions of general application which may aid in the treatment of hives already in possession, or in the selection of those yet to be purchased.

Most treatises say much with regard to hive-capacity, and, were we content to deal with those obsolete types that are quite inelastic, a determination of their correct size would be a most important matter. But, seeing that we simply replace the layer of warming bees (*wb*, Fig. 4), which is larger or smaller according to size of swarm, number of combs constructed, temperature of the external air, and a multitude of other contingencies, it is clear that our elastic hive, to do its best work, must not only be capable of adjustment, but must be actually adjusted, in so far as the economic use of the bee-keeper's time permits, to every cause for variation. While this adjustment, and the principles determining it, must receive attention at various points in our future studies, it is for us now to fix the maximum, beyond which our hive never need be extended. A few years since, a bushel (2218 cubic inches) was constantly suggested as the correct thing; but since, on the average, bees in so much space would devote it partly to breeding and partly to store, it may be accepted that somewhat less than this is abundantly sufficient for any one hive section, and, indeed, far too large where the interchanging of a horizontally-divided brood-chamber is practised—storifying permitting, of course, of such additions as special circumstances or a particular plan of operations may demand. Most hive-makers give ten Standard

frames, about equal to 1800 cubic inches, almost always sufficient, although even here circumstances alter cases; the bee-keeper, by example, working one way when he is increasing his apiary, *i.e.*, desiring to breed bees, and another when he has completed his number of stocks, and is looking for his return in comb or extracted honey.

The transit of hives from the maker's either risks damage or entails expensive packing. Many would do well to purchase in the flat, reducing not only risk, but prime cost and freight at the same time, beside which a little attention in the putting together, which the maker could not give, in consequence of the keen competition now obtaining, would triple the durability of the hive, and increase the interest of the owner. Take one example: Mr. Sproule informs me that he bores a $\frac{3}{4}$in. hole, about 2in. deep, into the end grain of the legs of the hive stand. The legs are now tied together, and stood on end, when each hole is filled with crude carbolic acid, which is rapidly absorbed. Fungoid growth and consequent rotting are, for a very lengthened period, prevented. Again, in putting together the body, painting the abutting edges is of immense utility; besides, the tone of colour may be made to the owner's taste. For coolness in summer, and warmth in winter, light colours are preferable, because these both radiate and absorb heat less than dark ones. There is a meaning in the whiteness of the Polar bear and Arctic fox. Bees have the colour sense strongly developed, and so they are considerably assisted in marking their location by variation in this respect.

Where hives are rather crowded together, the operations of the apiary (often involving the removal of a hive from one spot to another) will be greatly facilitated by having interchangeable roofs, made as dissimilar as possible in tint, while the whole of the hives are alike. Where a hive is removed, the roof remains, and so no difference is made in outside appearances, the bees, as a consequence, returning unhesitatingly to their old station, and entering the new hive as we desire. This object is achieved in some small apiaries, where tasteful arrangement is much considered, by having what may be termed loose boxes. These are each just large enough to receive a single-sided hive, and have a porch and alighting-board in front, with a door behind, and a hinged roof. The hives are carried from one to the other, as occasion may require. The loose boxes, being arranged at the first, remain always *in situ*, giving no indication of the disturbance practical operations involve, the bees, being, of course, cheated into the acceptance of any home we may choose to place in the loose box, which they have from use regarded as their own. While it is occasionally necessary that the bees should thus lose the identity of their hives, it is equally important that the bee-keeper should never do so; and, to that end, every hive body should bear a number with which it can be always associated in the mental or book notes made respecting it. Frames pass also constantly from hive to hive, and the bee-keeper should therefore carefully avoid odd sizes, which will actually deprive him of half the advantages of the movable comb system.

It is most important that the hive roof should be absolutely watertight: the slow drip from melting snow has ruined many a colony. In the event of a cover, through alternate swelling and shrinking, proving refractory, a cure may be thus made: Remove external battens, should such exist. Then, after drying, paint thickly, and cover with unbleached calico, tacking it at its edges, so as to remove all creases. Now apply paint upon the calico also, until it is soaked, when it will dry firmly adherent to the roof, which will give no further trouble. The cottager with slender purse, and with rude hive cover, may waterproof the latter with little outlay, by first coating it with hot pitch, over which he evenly spreads a sheet of newspaper. The application of a hot iron, used after the manner of the laundress, remelts the pitch, incorporating it completely both with wood and paper: all cracks are thus closed, and the cover made absolutely rainproof for several seasons; I have seen such in good condition after ten years' duty. This plan may even be applied to home-made hive bodies, the wood of which may be faulty, and the carpentry not of the most finished description. These processes must not be despised, although not æsthetic, for by such occasionally the poor man may be induced to enter upon better methods than those of his forefathers.

One caution is needed with regard to home-made hives. The body has the grain of the wood horizontal. If the wood be brought down, when green, to the correct depth, shrinkage will almost certainly lessen disastrously the bee-space beneath the frames. No

injury will result from having this even $\frac{3}{4}$in., so that more should be at first allowed than the customary $\frac{3}{8}$in.

Little has been said of the material most fitted for bee-hives, for the general suitability of wood has been long attested by its practically displacing every other substance. Straw is cheap, a good non-conductor, light and elastic, and easily moulded into walls with curved outlines; but it cannot readily and accurately be made to take the rectangular form so inseparable from the movable comb system. Rushes, sedges, earthenware, plaster, cork-bark, dried mud, have all been used, but where apiculture has become a science, wooden hives alone are employed. The non-conductivity of porous bodies depends much upon the amount of air interlocked in their substance, and hence light and porous wood is far better for hives than that which is dense and solid. Pine is usually employed, but willow, poplar, or lime, would be almost equally suitable. With a double skin of such woods, filled in between with charcoal-powder or cork-dust (see page 60), we have a hive wall which cannot be equalled.

In conclusion, the hive is but an instrument which is not automatic. It may be of the correct size and shape, and of appropriate material, giving our bees most efficient protection, and affording every facility for manipulation; but the observant and attentive bee-keeper alone will reap from it, and the bees it contains, all the harvest they are capable of supplying.

CHAPTER IV.

NATURAL INCREASE.

The Effect of Advancing Spring: Breeding Increased —Premonitory Signs of Swarming: Drone-raising; Queen Cells—Excitement of Swarming—Settling —Tanging: is it Useless?—Hiving—Fanning and Intercommunication—Difficulties in Hiving—Swarm-Box and Bag—Scouts — Queen-catching — Wing-clipping—Piping—Casts—Plurality of Queens—Peculiarities of Casts: Consist of Young Bees; Build Worker Comb—Risks Attending Casts—Absconding Swarms.

BEES, in partial sympathy with sleeping Nature, spend the winter in comparative inactivity, and breeding is for a period suspended; but as the sun begins to climb the heavens, and the days lengthen, the colony is roused, and initial steps are taken to prepare for the labour of another summer by stimulating the queen to provide eggs. She, moving round and round in a spiral upon the cell first furnished, enlarges her brood patch, while the dense cluster into which her children have been driven by the biting air during weary months of waiting, begins to expand, and those that have been pressed together for mutual warmth

soon circulate singly upon their combs, gathering in from outlying parts the stores that their renewed activities demand. The slain, during the fight with relentless frosts, are carried forth, and water, for thinning down the inspissated honey to fit it for brood-feeding, is eagerly sought by little gatherers, who often venture to face the yet chilly wind at the cost of their lives. Now the first spring blossoms open their dainty cups, and the industrious creatures fly in the sunny hours with impassioned earnestness, bearing home upon their thighs high-heaped pollen masses for the nourishment of their dependent young. The fruit-trees at length put on their spring dress, and countless blossoms yield abundant food. The old workers receive the aid of their recently-hatched sisters, and honey shows its glistening face in many a cell. The queen is beginning to put forth all her power, and population and wealth increase together. Should prosperity thus flow on, there will be no place found in which to bestow their goods, and the necessity for colonisation at no very distant date begins to be recognised.

Eggs have hitherto been deposited in none save worker cells, but, with a division of the colony, males will be needed to fecundate the young queens. The larger cells are, in consequence, sought out, and soon big drone grubs are the object of the attentive care of the nurses. The spring production of drones may thus be accepted as one of the signs of prospective swarming. Ere long, the queen finds barely sufficient cells to receive her abundant eggs, and now preparations are started for supplying the place of the old mother, who

must needs accompany the intending emigrants. The large, pendulous queen cells (see Fig. 3 and page 27, Vol. I.), rarely less than three or more than thirty, are commenced in succession, and when the first-started of these are sealed, we may consider that the time of departure is at hand; this period, in our latitude, usually running from the middle of May to the middle of June. If the bees are over-crowded and insufficiently ventilated, they may come off soon after their queen cells have been commenced, or even—though very rarely, and that in the case of yellow bees—before queen cells have been started. Unfavourable weather may delay their exodus, and should this be continued until the maturing princesses are within a couple of days of leaving their cells, the latter are cut down, and swarming for the time prevented.

On the morning of the day fixed for departure, gathering is not wholly suspended, as some have said, but it is much relaxed, as is proved by the "hanging-out" cluster (a common accompaniment of small hives when crowded) not being reduced in size, as the day advances, by the departure of its bees to the fields. The unusual quietude is quickly changed to tumult. Some tell us that a signal within is given, since the teeming thousands seem to be seized simultaneously with some violent agitation; but of this, it is best to confess, we know nothing, except that the bees about to leave the place of their nativity for "pastures new" commence to run about the interior of the hive in wild excitement, vibrating the wings, held high above their backs, while even the nurses of the brood nest appear, for the nonce, utterly disorganised, rush-

ing hither and thither with the rest. The would-be emigrants are not, apparently, unmindful of the necessity for preparing to the utmost of their ability for the contingencies of their expedition, as every bee about to depart fills to repletion her honey-sac (pages 18 and 60, Vol. I.), by which, with economy, she will be able to supply her true stomach with food for at least a week. There is also abundant proof that, in premeditated swarming (if such a form of expression may be allowed), the wax-secreting organs (page 155, Vol. I.) have for some days been under stimulation, and that wax plates are already being formed under the abdominal rings. The interior excitement has the evident advantage of making every bee aware of what is to transpire, so that all can prepare and act in concert. They now rush to the entrance, literally pouring forth in an impetuous current, which sweeps into it toddling youngsters, yet too weak to fly, and which are simply dropped to the ground from the alighting-board. A cloud of merry hummers, circling widely, fills the air with an indescribable rustling murmur. More are yet crowding through the narrow doorway, and, as we watch, we may catch a glimpse of the queen herself as she takes wing to join her children; for the common idea that the queen issues first, and the bees follow, is, at least as applied to first swarms, quite erroneous. We note that the giddy multitude now begins to somewhat concentrate, and to make a progress in a definite direction, and, taking this as our cue, we glimpse the chosen spot for alighting already blackening with bees, the mass each moment growing, until nearly all

are settled, and the uproar of the previous minutes at an end.

The fashion of rattling keys and frying-pans is a thing of the past. The ancient ringing of bells and making of noises may have had no object but to warn neighbours, and to sustain proprietorship in the rising swarm; but I believe that the old idea, now almost universally discredited, that these noises disposed the bees to settle, is accurate. The investigation of undoubted auditory organs in the antennæ (pages 107, 108, Vol. I.), the difference between the flight-note of the queen and that of the worker, experiments made on small swarms and divided stocks, and the observation that bees choose quiet times—Sundays notably—for their departure, all point in one direction. Langstroth tells us that, if a swarm is disposed to take a longer flight than desirable before settling, it may be brought to earth by throwing dust among the intending fugitives; while he and others also have stated that flashing a sunbeam from a looking-glass amongst them will have the same effect. I have used a large garden syringe, as I believe with advantage, in this relation.

When the swarm is once fairly settled, our object should be to keep it cool, for the universal excitement and close packing of the cluster raise the temperature to an almost unbearable extent, and the direct rays of the sun may drive it to a new and, for us, most inconveniently lengthened flight. If the settling-place is in a bush, and we cannot proceed to hive immediately, cover the bush with a sheet, and, in very hot weather, sprinkle this, and the bees also, with

water. The damping must not be a drowning, but, being ample, it will bring the bees into closer contact and aid us in dealing with them. If a tree has been chosen, an umbrella thrust in amongst the branches will give the welcome shade. Bees at swarming-time are nearly always in the best of temper; but the statement that they then will *not* sting is an utter and very misleading mistake (see page 12). The novice should be veiled and gloved, even if the position taken up is a convenient one, such as the end of a bough. Should the swarm be intended to remain in a skep, it had better be hived into the one it is to permanently occupy. If a frame hive is to receive it, let it be first secured in a skep, and then transferred as hereafter described. We have just said that the end of a tree bough is a convenient position. Let us suppose that we have a swarm so situated, and that it is not above our reach as we stand upon the ground.

Provided with a small towel, or other similar article, a skep (which should be clean within, and free of all "beer and sugar" abominations), and a large stone or 2in. wooden block, we are ready for action. With one hand we hold the skep inverted immediately beneath the swarm, and so close to the latter that the point of the cluster is near its crown, whilst, with the other hand, we grasp the bough as near as possible to the bees without crushing any, and, with a short and quick down and upward movement, we shake as many of the insects as possible into the skep. The novice would expect every bee to fly: some few hundreds will do so, and career around; but the great

bulk, powerless in reciprocal embrace, as they hold one on to another by the marvellous anguiculi, or claws, we have already studied (page 124, Vol. I.), fall in mass, and are directly under control. Did we give them time to recover from their surprise, and to disengage themselves, they would commence to run up the sides of the skep, and roll over its edge like boiling milk in a saucepan; to prevent this, we, as immediately as possible, drop the towel over the skep, holding the former in position by its corners.

If the spot the swarm is to permanently occupy be near, we may walk to it at once or not, as we please; but the next step is, without releasing the towel, to slowly turn the skep over, placing one edge of it on the stone, and the other on the ground. The towel is now allowed to fall to earth, its corners being laid flat, so that the bees may not get beneath it, but have a convenient platform by which to enter their new home. A board may be substituted for the towel, or both may be omitted should the earth at the spot be fairly smooth and not dusty. If, after the subsidence of the temporary commotion produced, we find that the bees are beginning to draw near to the hive, flying about the gap between it and the towel in a spirit of inquiry, and then entering, while those on the bough seem excited and bewildered, running hurriedly about, and now and again taking a little turn on the wing, we may conclude that we have secured the queen, and that, before long, all will be comfortably clustered within the hive. We shall observe now, on the outside surface of the skep, and on the towel, a small army of fanning bees, all

heading towards the opening. Singularly, no writers mention what I have always observed—viz., if the queen be within, bees continually issue from the skep, running from fanner to fanner, in alternate diagonals, giving each one two quick taps with the antennæ, which seems to me to convey: "All right, keep it up; mother's at home, but she's terribly hot." The fanners, thus encouraged, do not relax their exertions for a moment.

If, instead of these assuring indications, the bees within the skep are apparently disquieted, and begin to leave it in numbers, the fanners also, lacking information, impatiently stopping their work, and running about, whilst the mass on the bough is comparatively tranquil, and evidently increasing in bulk, we may be pretty sure that the queen is not in our party, and that the previously-described operation will have to be repeated, for, ere long, the bees will desert our skep and join their comrades who have the queen in their keeping. We may, in this case, often save ourselves trouble by at once re-hiving the residue as at first, in anything at hand—*e.g.*, a big flower-pot or pail (my hat has been pressed into the service more than once)—and adding the second lot to the first, by pouring or shaking it out against the opening beneath the skep; but excessive meddling must be avoided, as bees under constant disturbance are unable themselves to ascertain the whereabouts of the queen, the spread of information on this point through a swarm requiring several minutes at least.

Hiving under the circumstances described is a most simple matter, the operation itself being but the

work of a few seconds; but difficulties are at times met which tax both the patience and ingenuity of the bee-keeper. If the point of settlement be a bough at a considerable height from the ground, the easier plan is to place a ladder so that the bough may stand over the shoulder of the climber, who saws through the limb with as little shaking as possible, and now descends with the bees over his back. Unless very roughly disturbed, the swarm is not likely to depart during the operation; but it is, nevertheless, wiser to use the syringe cautiously before the sawing is attempted. Should this have been impossible, let the bees now be sprinkled with water, and then dropped, by a sudden shake of the bough, immediately in front of the hive to be occupied, which has been propped up an inch or so to give them ready entrance. Should they not turn to march in at once, scoop up two or three lots with a large card, and shoot them, with gentle violence, under the hive front. Their joyful note, indicating that they have found a house to let which just suits them, will immediately draw on the rest to take possession.

The difficulty just supposed may be surmounted in other, perhaps better, ways. Fixing the skep on a fork, holding it aloft beneath the swarm, and banging the bough with a long-handled rake, has been suggested by a well-known woodcut; or the Shepherd swarm-taker and hook (A and B, Fig. 40) may be used. It consists of a lidless $\frac{1}{2}$in. box, 8in. square at top, and 16in. deep, put firmly together, and bored on all sides with $\frac{3}{4}$in. holes, and having passed through it a strong, light pole. The second pole

must be of corresponding length, with a stout hook (*h*) fastened at the end of it. Hold the box close under the cluster, and jar the limb once or twice with the hook, and the operation is completed. Lower the box carefully, and pour or shake the bees out in front of the hive to be occupied. If the bees need be kept waiting for their permanent home, put the box on the ground, and cover it closely with a sheet. The defect in this swarm-taker consists in its being fixed to the pole, so that it cannot be kept in the

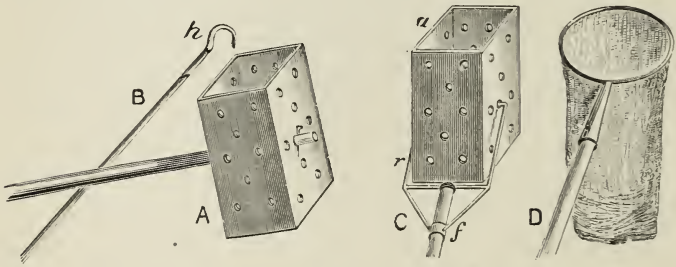


FIG. 40.—TOOLS TO SECURE SWARMS.

A and B, Shepherd Swarm-taker and Hooked Pole—*h*, Hook. C, Cheshire's Improved Form of Swarm-taker—*r*, Iron Rod; *f*, Ferrule. D, Canvas Bag for Swarm-catching.

desirable perpendicular position when placed under the bees. My arrangement (C) overcomes this difficulty. The thin iron rod (*r*) passes loosely through the box, above its centre of gravity, so that the latter always rights itself, whatever may be the position of the pole; while to pass it through any opening, between branches by example, the box can be kept horizontal by putting the side *a* downwards. The holes in these boxes have quite a fascination for the bees, while they supply such abundant ventilation that the cluster remains contentedly within. Some

use and recommend a bag (D) made of cheese-cloth, instead of a box. The swarm is dropped into the bag by cutting it gently from its attachment by means of the iron ring, which is then turned edgeways, so as to hold the bees prisoners while they are carried to their hive. To get rid of the bees, the bag is turned inside out. The disadvantage here lies in the liability of the bag to catch on every projecting twig, and to become hopelessly contorted amidst branches.

These forms of apparatus have the one virtue of being very rapid in action, but would be only rarely of service, except to large owners in favour of natural swarming, to whom the quick disposal of each colony is important, as reducing the liability of swarms uniting—a veritable nuisance, hereafter considered. We may, in the absence of special appliances, operate thus: Firmly attach two or three small, leafy boughs to the end of a pole of sufficient length to enable us to reach the swarm, and provide another pole, furnished with a hook. Push the leafy bunch in amongst the cluster, and allow a minute or two for the bees to attach themselves to it; now draw it back gently, carrying as much of the cluster as possible with it, holding those we have secured near to, and, if practicable, somewhat beneath those hanging in the original place of settlement, so as to catch at least part of those whose fall we intend to compass. Now shake the tree limb with the hook, throwing off all the bees remaining upon it into the air. Those on the wing, anxious to join the majority, settle at the end of our pole, and are soon so

clustered there that we may walk away with them, and hive as before.

Bees sometimes gather around the main stem of a tree where many branches are given off, and where dislodgment by shaking is impossible. The skep may, in some cases, be pushed in, and fixed over them, and they driven towards it by smoke. At the same time, they may be coaxed by a piece of comb containing brood, or store, fastened firmly within the skep. In such cases I have succeeded better, as I think, when the floor board has been added, so as to leave a very wide entrance. In one instance in my experience, the bees passed in so slowly that not until nearly noon of the succeeding day could the skep be removed. Brushing with a goose wing, which many recommend, I have never found useful; agitating a weed, such as a dock head, amongst them, much more quickly makes them travel upwards: but it is impossible to give specific rules for every case; much must rest with the ingenuity of the operator.

Should the swarm be intended to stand near to the position in which it was hived, it should be removed thither as soon as the main body have taken up their quarters, for two reasons: First, After swarming, bees carefully mark their new location, and those taking a flight before the hive is placed on its stand are in danger of being lost, by returning to the wrong spot; Second, There is abundant evidence that bees, at least occasionally, send out scouts to hunt out a suitable domicile, and, should these return from a successful trip, they will, in all likelihood, conduct our swarm to the nesting-place of their choosing; and is it not

impossible to believe that such retreats as those mentioned at page 30 could have been detected without some organised plan? Moving the swarm to its destination during the absence of the scouts will leave the latter as lost bees, when they will probably re-enter the stock whence they originally came. In newly-settled countries this difficulty will require to be more carefully guarded against than in our own. Not a few instances are also on record of bees coming out and, without settling, making off to some distant, hollow tree, or taking direct possession of an unoccupied hive with,* or even without, combs, seeming to involve that the selection had actually been made before the day of swarming. On the other hand, circumstances show that the would-be colonists commonly commit the future to the keeping of the fitful goddess, and just await what may turn up. I well remember a very late swarm, of unknown ownership, presenting itself on the extremity of an upper limb of a tall chestnut, and, wetted by rain, swaying about, in a strong wind which sprang up, until the third day after settling, when I, in sheer pity, hived the nearly exhausted insects, which, under kind treatment, afterwards did well. The semi-abortive attempts made by unnoticed swarms at establishing a home in the open (page 30) can hardly be explained upon any other supposition.

* A hive with empty combs is so exceedingly likely to be adopted by a swarm that such, it is said, have been used as decoys, with the most disreputable object of trapping swarms from neighbours. In one's own apiary, such hives may possibly act as helpers, and were often recommended in the days when bees were left to take their own line with regard to colonisation.

If the swarm we have just hived is to be taken any considerable distance, it may be packed so soon as the bees have collected within, or be left till evening. A piece of coarse canvas, known as "scrum," should be spread out smoothly on the ground. The hive, now lifted cautiously, and kept quite upright, so as not to break the cluster of bees hanging from the roof—much in form like a swallow's nest under the house eaves—is placed upon the canvas, which is drawn up round its sides, and tied with string. The skep is now inverted, and may be carried with safety, both to porter and bees, to its destination, or conveyed by cart or rail, the essential point being that the canvas is kept upwards. It is well here to mention, parenthetically, that a swarm confined as described in a skep, is exceedingly likely to perish if the canvas be beneath, even if the skep be held high in air; for, if the cluster be broken, the mass of bees lying upon and pressed against the canvas stops ventilation so completely that the upper individuals get asphyxiated before they can crawl up the sides, so as to relieve their companions, which are held down by their weight.

The skep, upon its arrival, should be placed on a bottom board, and slightly raised by a stone inserted beneath its front edge. The string is now untied, and the canvas released from the mouth, but not removed until the bees have had time to get clear of it by clustering above. Where bees have to travel, the preferable plan is to first place them in a swarm-box (see "Artificial Swarming").

It was previously stated (page 128) that, if a

natural swarm is intended to tenant a frame hive, it should still be taken in a skep. We have, therefore, to explain how to pass the bees from the latter to the former. Spread out upon the ground, as near as convenient to the final station, a tablecloth, sheet, or opened-out newspaper, stretching it as smoothly as possible, and fixing down the corners by stones or wooden strips, so that the wind may not disturb it. Place upon this the frame hive, from which the bottom board has been removed, so that its back comes to the edge of the cloth, or paper, giving a considerable unoccupied area upon which to throw the swarm. Prop up the front of the hive with a stone, or block, at each corner, leaving about an inch space, by which the bees may rapidly enter. Cautiously raising the skep with the contained swarm, and standing with the feet well asunder, while holding the skep firmly between the open palms, with a sharp, sudden, and decided jerk, shake out the bees upon the sheet close to the hive. By repeatedly dropping, as it were, and catching again, the skep between the hands, beat out of it the few dozen remaining bees. The fallen swarm, startled, does not attempt to take wing, and for the first three or four seconds merely spreads out upon the sheet, after the fashion of a semi-liquid mass; but the suitability of the hive is immediately recognised by the party advancing into it, which at once starts a joyful note, calling the whole body to the newly-offered home, towards which, in a moment, and as if by magic, every head turns, and the march progresses until all are safely within. Sometimes,

there seems some hesitation, or the bees make an advance not quite in the direction desired, difficulties which may be left to right themselves, or which may be immediately remedied by the scooping process previously explained; and, unless the handling be rough and careless, not a bee will sustain injury. Sometimes, the rapid onward march (especially with hives that have a fixed bottom board) may block the entrance, and cause the bees to gather densely on the hive front, whence they may be dislodged by brushing with a feather, or, better still, scraping with a card; but a little patience will generally be found more serviceable than too much anxious fussing. The observed entrance of the queen is an end to troubling, as all are sure to follow. With hives with fixed legs, a large board, propped up to the entrance, will replace the sheet, and all will proceed as before. Instead of these plans, the cover may be taken off, and the cluster thrown down upon the tops of the frames, one or two of which have been removed; but the bees are so likely to "boil over" the hive sides, that beginners are not recommended to try it.

Cases now and then occur in which bees, after having entered a hive, appear to be dissatisfied with it, and refuse to remain. My late friend, Mr. John Hunter, recounts that he hived one lot of bees no less than six times, on six consecutive days, before they submitted to the inevitable. In such cases, an unfailing cure, consists in giving a frame of unsealed brood, rather than desert which the bees will brook a hive not to their fancy.

Sometimes, swarms issue and, without apparent cause,

return. Perhaps their queen has defective wings, and is unable to fly. The fact that, in these cases, the bees do occasionally cluster, raises the question, Is the queen the predisposing cause of clustering? I decidedly incline to the supposition that the bees are, in such cases, the victims of a contagious error, started, perhaps, by a goodly number settling at one spot, which error cannot be dispelled until all have quietly collected; and that, normally, the queen *is* the cause of clustering, in the sense that she is tempted or conducted along to the chosen spot, some settling first, to give her encouragement. She joins immediately, and continually rises to the surface of the mass, as external layers are added to it. On two or three occasions I have actually witnessed this order of procedure. In the event of a threatened return, or when the bees, after issuing, continue in great commotion without decidedly settling, search may be made for the mother on the ground in the neighbourhood of the hive, where she will often be found, accompanied by half a dozen or a dozen of her children. Placing her upon a convenient twig, in the spot in which the bees are most dense, they will probably soon gather around her; and this will they equally do if she be retained in the hand, though perhaps few would trust sufficiently the harmlessness of the experiment to try it. By removing the hive whence the swarm has been thrown, and putting in its place an empty one, and laying the queen near the entrance after caging her (see "Queen Cage"), nearly all trouble is avoided. The bees, returning, find the queen, and gather about the cage, when she

may be liberated, that mother and children together may pass into their new home.

By carefully looking over a hanging swarm, the queen may often be seen walking over its surface, and occasionally passing into the interior. I am led, however, to remark, from constant observation, that the queen is not by any means always seen at the lower part of the collected mass of bees, as one writer at least has ventured very positively to assert. So soon as a glimpse of her is obtained, she may be grasped quickly and tenderly, and treated as in the case just supposed. Many times I have so caught her ladyship, and, having imprisoned her beneath a pipe-cover cage of large mesh, fixed on to a side of a broken section by an indiarubber band, have brought the swarm back to her, and to the hive I intended it to occupy. Before carrying off the queen, it is well either to shake some part of the cluster off into the air, or to hold the cage in contact with it for a minute or two, when a bunch of bees collects upon it, attending to the queen's wants pending the arrival of the main body. Of course, after the swarm has returned, it may be placed in any position we please, since bees, under the swarming impulse, seem to utterly disregard the stock to which they previously belonged, and adhere to their new abode, wherever situated.

Although we are here discussing *natural* increase, a method must be introduced which is distinctly artificial. It consists in removing one or both of the anterior wings of the queen, so as to prevent her travelling to a distance to establish a new colony.

We have already learnt that, after fecundation, the queen flies only at swarming time. "Wing-clipping," as it is termed, therefore, in no way interferes with the queen's natural movements, the one case mentioned being excepted. When a swarm issues, she, in her attempt to soar with the merry throng, only falls to the ground in front of her hive, where the bee-keeper finds her making abortive hops, and may then secure his fugitive bees in the way just previously detailed. But the practical out-working of this arrangement is not always so beautifully convenient as the theory might suggest. No swarm can be lost, it is true, but the queen generally will be if the alighting-board of the hive is not continued to the ground, or if the bee-keeper be not at hand to take his part; and then the returning bees will rear a number of princesses, to possibly spoil his stock by leading off colonies one after the other, each of which is far more likely to be irrecoverable than the prime swarm accompanied by a full-winged queen. By reference to page 135, Vol. I., we find that the wings receive nutrition during the whole life of the bee, and that both nerves and large tracheæ pass into them. The removal of the wing may, therefore, not be so absolutely unimportant as some assume; although, judging from analogy, I am of opinion that it is not prejudicial, and that Professor Cook's suggestion, that the queen may be made even more vigorous through the excision, "as useless organs are always nourished at the expense of the organism," is quite accurate. Much, however, turns upon the ultimate condition of the divided trachea, and this, I believe, rarely closes. Many who

practise wing-clipping incline to the belief that queens thus maimed are more likely to be displaced than are those that are perfect; yet it is clear, on the other hand, that such queens may do duty for the allotted term of their existence.

The *raison d'être* for "clipping" is less with us than in America, where it is mainly in vogue, though even there some of the largest owners are against it. I have clipped but few queens, and think that our knowledge now of the principles by which swarming can be controlled make the process of so little service that its disadvantages quite outweigh its benefits. I shall content myself, therefore, by explaining the best method of using the scissors, for the enlightenment of those who desire to experiment. Since the costal nervure (page 139, Vol. I.) is the most highly organised part of the wing, while it has least to do with sustaining the insect in the air, it is best, perhaps, to remove as many as possible of the wing cells, leaving the costal nervure intact. If this be done with the anterior (larger) wing of one side, all balance is gone, and flight is impossible; but those who would maim æsthetically (?), say this interferes so much with the beauty of the queen, that it is best to give her a "symmetrical" appearance by cutting off the greater part of both larger wings. Those who are accustomed to handle delicate matters may finger a queen without the least risk of injuring her; and it is best to grasp the thorax so that the wings stand outwards, while the legs are confined, and our scissors will then make the cuts as we desire, especially if we somewhat glue the wings, by stroking over them a little honey with

the finger. If pinching the queen be dreaded, let her fly on a window pane, with three or four of her bees, until the latter caress and feed her, when the scissors may be applied ; but the risk remains that she, upon the touch of the steel, may raise her leg, and lose more than was intended.

We have as yet by no means exhausted the catalogue of methods intended, like the foregoing, to minimise the trouble, disappointment, and loss, associated so

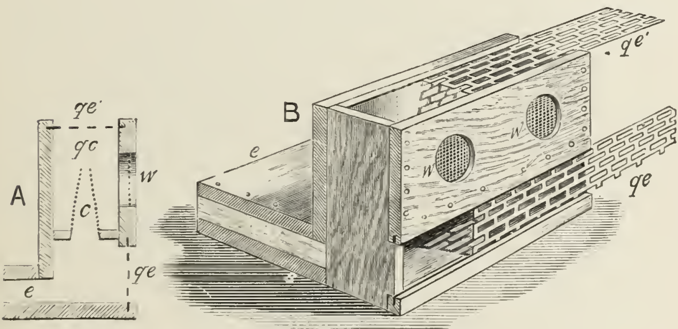


FIG. 41.—QUEEN-TRAP, OR SWARM-ARRESTOR (Scale, $\frac{1}{5}$).

A, Section—*e*, Entrance; *qe*, *qe'*, Queen-excluder Zinc; *w*, Wire Window; *c*, Wire Cone, with opening above; *qc*, Queen Chamber. B, Perspective View—Letterings as before.

frequently with natural swarming. Much ingenuity has been exhibited in devising plans for luring the queen about to depart, into imprisonment, so that she and the bees may be secured without difficulty. Although none of these can be recommended as undoubted successes, yet they cannot be altogether omitted from a treatise like the present. There is a common likeness about these queen-traps, or swarm-arrestors, but that used (Fig. 41) by Mr. Henry Alley,

of Mass., U.S.A., may suit our purpose, as illustrating the general plan followed. It is placed before the mouth of a hive from which a swarm may be expected, when the bees pass in at *e*, drawn on by the light streaming through the queen-excluder (*qe*), through which they readily escape, and by which they make their return. Should a swarm issue, the bees will suffer but little impediment, while the queen, failing to gain her liberty at the excluder, will try any opening that she may discover, and so possibly pass up a cone (*c*, A), of coarse wire cloth, freely lighted by a wire window (*w*), and by the openings in the excluder zinc (*qe′*) above it. Having passed out of the cone, into the queen chamber (*qc*), she will never discover how to return to the hive. Previous explanations now apply. Hives being changed, "the arrestor" may be stood before the front of the empty one, the side *s* preferably downwards, and the queen-excluder (*qe′*) towards the hive mouth, when the returning bees will gather upon it. Withdrawing the zinc half an inch or so will give the bees access to the queen, and, ere long, all may be expected to take possession of the hive. Drones, if numerous, will much interfere, and the queen may possibly fail to find the cones, of which there are only two; while the considerable alteration in the position of the entrance, suddenly made when the "arrestor" is placed *in situ*, not a little troubles the returning workers.

Mr. Howard improves upon Alley's idea by giving the queen-excluder (*qe*, A, Fig. 42) an arched form. The bees enter at *te*, the workers passing the excluder at once, and the drones or queen struggling

upwards, when the principal light is above, attracting them through the wedge-shaped opening (*we*) (which extends the whole length of the trap), to be securely caught. The returning bees cannot enter *w*, as the zinc is here of fine perforation; but the front of the hive is still hidden, and the change in entrance somewhat bewildering. How far I avoided these disadvantages in my trap (B), much older than those described, others must judge. I used it, in former years, to secure drones of the wrong sort, and found its action all that could be desired. Wooden ends

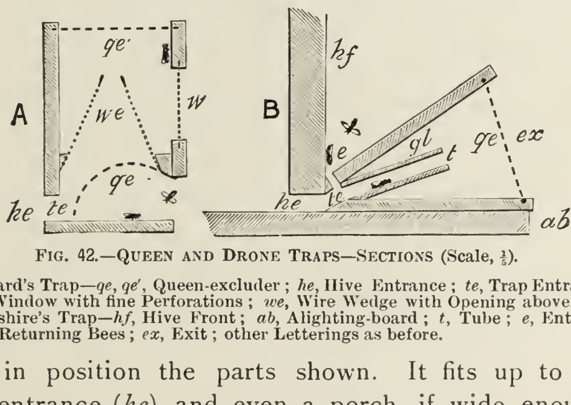


FIG. 42.—QUEEN AND DRONE TRAPS—SECTIONS (Scale, $\frac{1}{5}$).

A, Howard's Trap—*qe*, *qe'*, Queen-excluder; *he*, Hive Entrance; *te*, Trap Entrance; *w*, Window with fine Perforations; *we*, Wire Wedge with Opening above. B, Cheshire's Trap—*hf*, Hive Front; *ab*, Alighting-board; *t*, Tube; *e*, Entrance for Returning Bees; *ex*, Exit; other Letterings as before.

hold in position the parts shown. It fits up to the hive entrance (*he*), and even a porch, if wide enough, presents no difficulty. The bees march forwards, by the trap entrance (*te*), towards the light, ascending an incline of thin wood, with a piece of window glass (*gl*) over it, the two forming a narrow, flat tube (*t*). Now, flying to the holes, the workers escape, while the drones or queen remain. In returning, the workers quite naturally avoid the strange form, and walk down the known hive front (*hf*), to

join their companions, by the slit *e*, which is close to their usual door, and within hearing of the fanners. This slit requires no very careful regulation in width, since it is dark, and unobserved from within, so that no bees escape by it. The ventilation of the hive is unimpeded, every drone passing at once forwards, and the returning bees clearing the entrance immediately. These appliances may be useful as drone-traps, to secure possible mischief-workers found in purchased stocks, *e.g.*, or in temporarily preventing a swarm making off from a hive under suspicion; but they are more likely to suit the tastes and needs of the amateur than to find favour with those who look to honey-production as a serious matter.

Bees have the remarkable and, to me, unintelligible habit of swarming on spots that have been previously selected by other lots of bees. The suggestion is made that the odour of the queen explains the peculiarity. To make the suggestion is easy, but to accommodate it to the facts is difficult or impossible. Swarms are with me discouraged, and in some recent seasons I have had none; yet, when such come off, notwithstanding the interval, during which the leaves* have dropped to be succeeded by

* I freely admit that our sense of smell is relatively so extremely weak that we should err egregiously were we to judge by it of what the lower animals can accomplish; *e.g.*, it has recently been proved, by carefully-conducted experiment (Mr. G. F. Romanes), that a small fraction of a square inch of leather from the boot of the master is quite sufficient to establish an individually-recognisable trail for a setter dog; and, in addition, I would emphasise what every observer of bees must know, that the queen undoubtedly leaves an odour. On one occasion, I saw a fertile mother, lost by her swarm, resting on a leaf in a rose-bush; and this, for several days after, almost continually had bees upon it. The fingers that have handled, or the knife that has dissected, a queen, are very attractive; but

others, they go almost without exception to a wild plum, growing in a laurel hedge near by, which does not, so far as can be seen, present a more comfortable or convenient landing-stage than many dozens of trees and shrubs within sight of the stocks as they stand. The observed fact may, however, be of service to the novice who is wise enough to tempt his first colonists to a position of his own choosing; and, in this connection, what has been called the "bee-bob" may help in more ways than one. A dark-coloured mass, accidentally or intentionally resembling a forming cluster, brings to it bees that are intent upon not missing their companions, and these, by alighting, quickly convert the appearance into reality, and so the swarm is secured. Langstroth says: "By proper precautions, before the first swarms issue, the bee-keeper may so educate his favourites that they will seldom alight anywhere but on the spot which he has previously selected. The Rev. Thomas Hunt, of Wyoming, U.S.A., has devised an amusing plan, by which he says that he can at all times prevent a swarm of bees from leaving his premises. Before his stocks swarm, he collects a number of dead bees, and, stringing them with a needle and thread, as worms are strung for catching eels, he makes of them a ball about the size of an egg, leaving a few strands loose. By carrying, fastened to a pole, this '*bee-bob*' about

it must here be remembered that she, except in the rarest instances, does not touch the object upon which the swarm settles, as it is her habit to clamber over the bodies of the bees. May it not be suggested that the swarm, even after a short stay, leaves behind shreds of wax upon the twigs and stems, and that these, possibly, may have an effect?

his apiary when the bees are swarming, or by placing it in some central position, he invariably secures every swarm."

The obviously necessary instinct just referred to may, however, bring to the bee-keeper an entanglement not quite easily unravelled. The conditions which ripen one stock for swarming will be likely to similarly affect another; while the advent of peculiarly favourable weather may determine more stocks than one to leave at about the same time. And, in addition, the sound of a swarm in the air has a peculiarly exciting effect, often bringing out others that, without this stimulus, would not have left till days later; while nuclei (see "Nuclei"), especially if very weak, similarly prompted, often leave bodily. Under the united action of these causes, a union of swarms is not an altogether uncommon experience. Separation must be accomplished, unless one queen, at least, be sacrificed; although it is wise to remember that a doubled swarm, if early, will generally also be profitable. If two swarms only have joined, sprinkle well with water, and hive in a skep or basket as usual, and now arrange a sheet, spread flat, and two hives, instead of one, as before directed. Throw the bees upon the sheet, near its middle, and at a point equidistant from the two hives, again sprinkling gently, so as to thoroughly disincline the bees from taking wing. Now scoop up a small contingent for each hive, which drop down just in front, to draw on the rest. Have, if possible, an assistant, and carefully scan the thinned-out, advancing ranks, so as to catch sight of the queens. If so far fortunate

as to discover one, cage her immediately, continuing to so direct your bees that they are about equally divided between your hives. If both queens are seen, the plan is evident; but, missing the second, wait until one of the lots shows that it finds itself queenless, when they, of course, receive the now liberated prisoner. Should both queens escape unseen, still all may be well, for fortune may have been on your side; but if one lot is beginning to give evident tokens of unrest, an examination of the other lot may show you both queens balled—*i.e.*, inclosed in distinct masses of clinging, hissing bees, the size of a hen's egg, or even larger. Removing one of the lumps, and transferring it bodily to the orphans, will almost invariably put all right.

All your efforts failing, while it is clear that the bees of one hive are queenless, and are beginning to leave, they may be shut in, ventilation being provided for. Three or four taps then given on the side of the hive start a tremendous uproar, when any spare queen may be safely passed in at a convenient point, the roaring mass for the moment being held back by smoke. Next day the hive should be placed in its proper position, and the prisoners liberated. In these cases, "perseverance surmounts difficulties," and it may be wise, while one lot is held captive, to again shoot the bees having the two queens on to the sheet, securing another chance at hunting out the one in excess, as the troubled insects separately crawl past; and, if sprinkling be judiciously applied, but few will take wing. Should the bee-keeper have only entered his novitiate, and not yet have acquired the

faculty of recognising queens quickly, his best course will be to pass all his bees into a twin hive—one capable of accommodating two stocks (Fig. 16, *e.g.*). Removing the division (*d*), giving as much internal capacity as possible, and putting a comb in each of the two opposite ends, will prepare the hive for the purpose. When the bees are all within, remove to a cool place, and in the morning the two swarms will probably be found self-divided, and centred around the widely-separated combs, and with their own queen in each case. The union of swarms and casts does not admit of such easy treatment, as an unimpregnated queen is not so acceptable as a fertile mother. It is helpful, in most cases, to give a frame containing eggs and larvæ, and then, if the lot entering has no queen, it will remain. In a day or two, its condition can be ascertained by looking over the comb; and, if queen-cells are found, a new mother may be given, as explained under "Queen Introduction."

The importance of being able to verify the stock whence a swarm has issued must already have become apparent. This is not usually difficult, as, on the ground near the front of it, a number of young grey bees (page 126), which have been carried out in the stream, will be found wandering, or huddled together. An internal examination of the hive so indicated will confirm our supposition if we discover it to be queenless, reduced in population, and possessed, as it almost certainly will be, of queen-cells, some of which are sealed, as at A, Fig. 43.

In Chapter VI., the *making* and treatment of swarms

will be our subject; and, since artificial colonies are in circumstances altogether similar to natural ones, the method of aiding and best utilising our hived bees may well be deferred. The parent colony, however, now demands both our study and attention. Here we find a widely-extended brood-nest, comprising, perhaps, 40,000 or 50,000 pupæ,* larvæ, and eggs, testifying to the activity of the queen, who furnished this number of cells during the twenty or twenty-one days before her departure; and although, possibly, 20,000 emigrants have left, yet a sufficient number of bees, ordered by that hidden wisdom we call instinct, has remained to carry on the work of tending the multitude of advancing grubs, maintaining the temperature, and completing the work of raising new queens already in progress when the swarm left. Except under quite unusual circumstances, abundant honey is in store. Narrowing the doorway, to assist in husbanding heat, and to make the work of defence against robbers easy, is all that is required; and even this may be omitted, unless the weather should take an unfavourable turn. For reasons presently made clear, it is generally desirable, however, to place the swarm on the stand the parent hive occupied, and carry the latter to a new position. This adds to the swarm all the flying bees that had preferred "the old house at home," and, of course, proportionately weakens the parent stock, which should now be more carefully guarded against chill, and would benefit by

* Nymphs, or chrysalids (N, Fig. 4, Vol. I.); all these terms apply equally to the condition assumed after sealing, cocoon-spinning, and the last moult but one.

having very thin syrup, or water only, given to it for a day or two, to supply the nurses (page 19, Vol. I.), so that the younger larvæ may not suffer. Since no eggs are now being laid, in three days the amount of brood requiring attention begins to decrease, while population constantly grows; so that food, except in

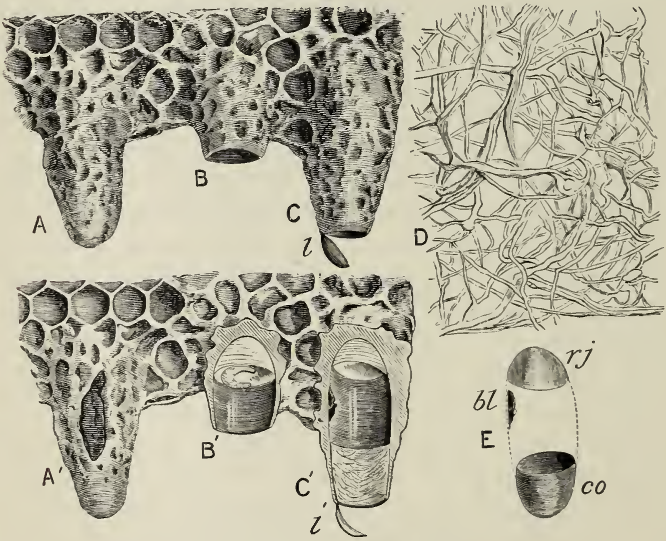


FIG. 43.—QUEEN-CELLS, COCOONS, AND ROYAL JELLY.

A, Queen-cell, Sealed (Natural Size). A′, Ditto, Torn Open, to destroy Princess. B, Half-built Queen-cell, containing Feeding Larva and Royal Jelly. B′, Section of Same, showing Contents. C, Queen-cell from which Young Queen has Hatched—*l*, Lid. C′, Section of Same, showing Remains of Royal Jelly, Cast Bowel, Exuvium, and Cocoon—*l′*, Lid. D, Portion of Queen Cocoon magnified 80 diameters. E, Contents of Complete Cell (Wax removed by Ether)—*rj*, Royal Jelly; *bl*, Bowel and Exuvium; *co*, Cocoon.

very adverse weather, will be gathered in considerable excess of the requirements of the stock.

Much that is new in reference to queen-cells has already been advanced (pages 172 and 241, *et seq.*, Vol. I.), but additional points, of practical importance,

as well as scientific interest, still await our consideration. Some of these cells, at the time of the departure of the swarm, are, normally, already sealed (A) (although considerable variations occasionally occur in reference to this matter), while in others (B) the nymphs are still feeding, and the object of, literally, unceasing attention, royal jelly (B′; *rj*, E; and page 82, Vol. I.) being added, in astonishing profusion, by a constant stream of workers inserting their heads in succession. At the close of the feeding stage, a sealing full of minute perforations is added by the never-weary attendants, when the well-fattened larva weaves within a cocoon (*co*, E), of very singular structure. That of the worker, or drone, is scanty, and consists of threads of tolerably uniform thickness (page 176, Vol. I.), while that made by the princess is heavily felted, and extraordinarily irregular. The fibres are a transparent brown, of every diameter between $\frac{1}{750}$in. and $\frac{1}{3000}$in. The threads, unlike those of the spider and silk moth, evidently remain for some time in a semi-fluid state, and so are partially confluent: while here and there droplets have been allowed to issue from the spinning gland, to fuse all together, as may be seen by a magnified view of a part of this structure (D). To obtain the cocoon, place the entire cell in ether (a rapid solvent of wax), and shake, with one or two changes of the ether, until every trace of wax has disappeared, when a pretty object for the microscope remains, whose general form is seen at *co*, E. So strong are these threads that, fixing the upper and lower parts of the cocoon between wooden slips, a 30lb. strain will not break them.

By dissolving the wax of the cell, we isolate the cast skin, and bowel and contents (*bl*, E), deposited by the queen against the cell side, and find these to stand just clear of the main mass of the cocoon itself.

As the inclosed princess approaches the completion of her wondrous transformations, the bees nibble away the covering of wax and pollen by which they, about a week previously, shut her in; so that a cell containing a nearly-matured queen may be generally recognised by its having the rough, felt-like, brown cocoon exposed. The fully-developed insect next frees herself of her almost impalpable exuvium (the last moult), and begins to bite through her cocoon, by means of her powerful, notched jaws. Turning within her cell, her bites are continued in a circle, until the end of the cell (or cocoon, rather) is all but separated as a lid (*l*, C), when the least effort from within—should the workers not resist—will enable her to make her escape. Often the lid is detached, but generally it continues hinged; and, should an inquiring worker pass in after the exit of the rightful owner, she may suffer as did the heroine of "The Mistletoe Bough," for, the lid closing upon her, the workers may add wax fixings, which accidentally compass her death. Many queen-cells, from this cause containing dead workers, have been sent to me by correspondents who have thought them extraordinary and unique. When so closed again, they may also be mistaken by the bee-keeper for those still containing queens to hatch, an error which may have disagreeable consequences.

The most advanced queen, having gained her liberty, and increased in strength during some few hours, manifests an anxiety to seek out and destroy her immature sisters; and, should the bees not desire to send out a second swarm (technically a "cast"), she is permitted to visit the royal cells, and assist the workers in tearing open their sides, just above the leathery cocoon, as at A′, when the helpless princesses are butchered, some of them at least, in certain cases, by thrusts from her sting, the utilitarian spirit of the workers impelling them to drink up the spilt "blue" blood of the nymphs ere their bodies are thrown from the hive.

The honey-flow continuing, and the population increased by all the hatching since the departure of the swarm, a further desire to colonise commonly yet exists, when the bees somewhat rudely check the right royal impulse of undying hatred to a rival, by keeping back the would-be murderess, as well as preventing those that are nearly as advanced as herself from leaving their cells, upon which they thickly crowd. Each of these princesses cuts her cocoon, the same as did the now free sister; but the bees put wax over the joint all round, except at one spot, where an opening is left, through which the tongue of the prisoner is now and again extended, that the workers may supply her wants. Whether the aspirant for queenship feels hatred, indignation, or fear, the writer does not know, and he thinks it unfavourable to progress that poetical fancy—almost poetical licence—has been mixed up so frequently with the facts he is now endeavouring to describe;

suffice it to say, that the lady under coercion gives origin to a sound which can easily be heard outside the hive—a sound comparable to, though happily much weaker than, that of a toy trumpet. It is a high-set, rasping note, likened to "Peep, peep, peep," and hence the word "piping" has been applied; but "Teet" and "Zeet" have seemed to some to better mimic the "vox regalis," which in France and Germany is represented by "Tuh" and "Quak," for that of hatched and unhatched queens respectively. To the piping call of the former, often described as a challenge, the latter replies with a duller, less metallic sound. These notes serve some purpose indubitably. They clearly have the advantage of informing the several members of this "Royal family" of each other's presence, and so tend to drive out those at liberty, should others in concealment be preserved from attack, at the same time that they keep the bees themselves informed of the general outlook, and of the points needing protection. They, in consequence, act as a guide to the bee-keeper, and, if continued a couple of days, may always be accepted as evidence that a swarm ere long will issue.

Singularly silent are all writers respecting the means by which piping is produced, but the problem is surely of sufficient interest to make it worthy of an attempted solution. Let us clear the ground, first by saying that the queen can, and does, pipe, although rarely, at all periods of her life, and not only under the above-given conditions. If held in the hand, or separated from her swarm, and caged (especially if several caged queens be put near

each other), the note is sometimes emitted; while if dubiously received, or threatened with encasement, when introduced to a colony as an alien, her peculiar, plaintive call is almost certain to be heard. From previous explanations of the causes of buzzing and humming, we must, I think, dismiss the idea of either spiracles or breathing-tubes having anything to do with this singular phenomenon; while the mouth, being merely an opening leading to the stomach, is necessarily incapable of any form of utterance. It is certain, also, that the wings are not concerned in its production, since queens clipped so vigorously that not a vestige of wing remains can be as noisy as others. Many insects, and some spiders and crustacea, are favoured with natural musical instruments, formed of hard, wrinkled surfaces, denominated "stridulating organs," which, by certain and varied movements of the bodies of the possessors, evoke grating, creaking notes. I remember Professor Stewart showing, about a year since, at the Linnæan Society, the stridulating organ of the spiny lobster (*Palinurus*). The file-like bow was exhibited under the microscope; and a male carapace, kept soft by glycerine, produced, when rubbed, the peculiar screeching rasp — something between the torture of the saw-sharpener and the quack of a duck—which is apparently so touchingly beautiful to the female *Palinurus*. To take only one other example: in the small, yellow, meadow ant* (*Lasius flavus*) the third abdominal segment is

* Sir J. Lubbock's "Ants, Wasps, and Bees," page 230.

laterally thrown into about ten irregular ridges, each approximately $\frac{1}{1000}$in. across, and these would seem, from analogy, to enable the insect to produce a note inaudible to us.

Careful microscopic scrutiny of the bodies of several queens (although, unfortunately for this purpose, I had only dried or preserved specimens), leads me to the belief that their piping is actually an effect of stridulation resembling that of the ant. The chitine of the lateral portions of the third and fourth abdominal plates has its scale-like character (see D, Fig. 22, Vol. I.) greatly changed. It is here hairless, and the individual scales are enlarged from $\frac{1}{1800}$in. to about $\frac{1}{700}$in. in width, and have their surfaces abruptly bowed at right angles to the axis of the body, so as to give a form which appears to me, after examining stridulating organs in other creatures, capable of stridulation. To view the nature of these parts, very strong and oblique reflected light is necessary. This position is made the more probable from the remarkable incurved character of the edges of the plates, which would rub on the file-like part if the hypothesis be correct. The position and arrangement of the apparatus would fully explain, too, the muscular tremor observed by many, myself included, to accompany piping. Some have described this as the movement of bellows held sideways; others have compared it to the working of an accordion. No other part of the body, so far as I have been able to discover, suggests, by its conformation, that it could be employed in stridulating, save the joint of the collar (the junction between the pro- and mesa-

thorax), and here eight or nine delicate line indentations occur; and possibly the tremor of the abdomen may be accompanied by a rasping of these loosely-articulated parts, so as to increase the sound. The difference between the note of the queen at liberty and the princess in the cell needs no further explanation than the obvious one, that the voice of the latter is muffled, while her body-rings are yet soft, and, consequently, less resonant.

Piping, which cannot be mistaken for any other sound made by the bees, may be heard by placing the ear against the hive, on the morning or evening before the issue of any swarm after the first; and as the first cast usually comes off nine* days after the swarm, let the bee-keeper listen, as described, on the evening of the eighth day, when, if piping be heard, it is certain evidence of the intention of the bees, which may, however, be frustrated by unfavourable weather obliging them to permit the destruction of the supernumerary princesses. Yet the lively maidens are less fastidious, with regard to the state of the elements, than the matrons, and, instead of waiting for the sun to near the meridian, as old queens mostly do, they are sometimes off four, or even five, hours before noon, or may delay their departure till near evening. Family jealousies, perhaps, account for their indifference to external conditions, for danger at home seems to drive out the free queen, or queens, which, after piping awhile, go *first* with such as see well to accompany them. The presence of more

* The queen cells remain sealed eight days before the contained queen hatches out. This determines the period of nine days.

queens than one is accounted for in one of two ways: Either two or three, perhaps several, queens have been allowed to hatch; or, during the excitement of colonising, some of the cells which had been guarded have been left, and the contained princesses have escaped, and flown immediately.

The queens which leave their cells without interruption so soon as they have carved their cocoons are not fit at once to take wing; but those held back by the workers toughen and strengthen in confinement, and are able to fly the moment they are free. Last spring I raised in a stock a number of Carniolan queen-cells, which were all, save one, transferred to other colonies, while a queen was already at liberty in the hive. The latter I carried away on her comb to form a nucleus (see "Nuclei"). Returning to the stock, I lifted up the frame carrying the queen-cell, to judge of its condition. The queen had been kept back, but her guards, being disorganised by the movement, permitted her escape, when she instantly flew, and the bees as immediately began to rise in a cloud from the opened hive, to form her attendants. They clustered in due form, and were as soon as possible returned. Here we note that the virgin queen went *first*, the bees following; that, as a delayed queen, she was strong for flight when hatched; and, next, that the bees, unaware of the loss of the queen at liberty, continued to so treat the one in the cell that she hastily left the colony, although she thus rendered it queenless. Why, also, did the bees, without an appreciable interval, follow her as a swarm? Is not the conclusion

irresistible, that the sound of the queen's flight (distinct to trained human ears) led them off? We need no argument to prove that bees hear, for we have already studied the structure of the auditory apparatus (page 107, Vol. I.).

After the issue of the first contingent, queen-cells still remain, which now and again are permitted to hatch in turn—a mania for colonisation seeming to get possession of the bees; so that a succession of after-swarms comes off during several days, extending, in rare instances, to the utmost limit of the eighteenth, or even twentieth, after the departure of the old queen. These are generally so weak in numbers themselves, while they so depopulate the stock, that neither they nor it are of much service—at least, for the current season. Thirteen years since, I had four after-swarms in five days from one hive, which afterwards filled a fine super, while all of the casts, with no additions of brood or combs from established stocks, became strong colonies; but this was quite exceptional, and, after all, was secured by the kind of attention which bees do not always get.

The exodus of the first after-swarm is generally followed by the destruction of the queen-cells. Sometimes, fights between hatched queens occur; and these are serious affairs. The amazons having once fairly met and grappled together, one at least must die. But the over-circumstantial accounts of "royal duels" (see "Queen Introduction") made by some of the older writers are clearly rather imaginations than facts. One, *e.g.*, amusingly describes how "they glare at each other, like two fencers intent on securing first

chance," quite forgetting that the interior of the hive is in darkness. Another, telling of the distresses of these royal personages, explains that, "during all the days piping lasts, not one of the princesses ever closes an eye in sleep," a statement which is faultlessly accurate, since they have no eyelids.

The swarm collects into a single compact cluster; but the cast, which has often more than one point of congregation, may make two, or possibly three, masses, which are almost always sufficiently near to each other to be, at some point, in actual contact. If, in hiving, one queen is secured, so that the cluster remains while another queen, at least, is left, it is needless to strive to bring all into one mass, as in the case of first swarms; and if we desire to secure or utilise the queens, it is better that the two lots stand temporarily side by side.

The bee-keeper who is anxious rather to obtain honey than increase, may return his cast, even if he cannot determine the stock whence it came, by picking off the accompanying queens as the cluster hangs, or by sprinkling and hiving, and then hunting out the queens, by shaking the bees round in the inverted skep, and beating them down from the sides by occasional blows outside from the hand, or by giving the top of the skep a bang on the ground. The poor insects, so treated, will become terrified, and absolutely harmless, the queens being usually seen as they are turned to the surface. When all queens have been secured, the bees will cluster in the hive (now stood upright); but, twenty or thirty minutes later, discovering their condition, they return to the

old home. Should the bee-keeper, however, know at the outset the stock whence the cast issued, it may, after hiving, be stood next its parent till evening, and then returned, by being thrown down in front, on a board or sheet. Yet this does not always end the trouble, the performance often needing to be repeated next day. Even if the queens in the cast have been captured, other cells hatch, and off may come new lots—possibly, as we have already seen, to the number of four or five.

A better plan is to frame hive in the usual manner, and stand the cast as close as possible to the original stock, both doors facing one way ; or, if the hives have not fixed legs, one may be placed on the other. In two, or at most three, days, with very rare exceptions, all the queens, save one, will have been killed, both in stock and daughter. The queen in the latter we now remove, and then unite, either by putting all frames into the one hive, giving a little smoke, or by brushing the bees from their new worker-combs on to a board or sheet. Should we need young queens, we modify our procedure, and wait until mating has taken place, shutting the bees up, meanwhile, to few frames, so that all are covered. Now remove the queen, and introduce where required, and unite as before. A couple of casts, individually weak, and from different hives, if only of about the same age, may often most usefully in this fashion be made to furnish beautifully regular worker-comb (since casts build worker-comb only, unless they should lose their queen), and a supernumerary young fertile mother; while their union will make them into a good and strong stock.

Even the best of these plans is too troublesome to be to the taste of those whose aim is profit rather than amusement; to such, the *prevention* of after-swarms is the important point. Cutting* out all queen-cells save one has been given as a specific, deferring the operation until five or six days after swarming, so that no eggs or grubs capable of being converted into queens may remain. The queen-cell elect should be built on worker-comb, robust, long, and symmetrically rounded at the end, like A, Fig. 43. The short cells, abruptly terminating, and sealed diagonally to their length, should always be destroyed, as they yield queens only partially differentiated from the worker, as I have anatomically proved (page 80, Vol. I.). But the process is not an absolutely certain preventive, since, very occasionally, the one queen resulting will come off, and leave the colony destitute. The cutting-out of queen-cells is, moreover, subject to misadventure. It is difficult to find all, and those passed by will usually be the small, ill-placed, and inferior ones, yielding those poor queens which, through our meddling, possibly get a chance of deteriorating our strain of bees. Sometimes, the one cell left does not hatch; and, again, even the keen-sighted may leave, and depend upon (page 154) a cell that has already furnished a queen.

It has previously been pointed out that it is wise to put the swarm on the stand of the parent colony, which is carried to a new position, and thus loses all its bees as yet old enough to fly. This greatly

* A gash with a knife, certainly killing the larva, is all that is needed.

aids the swarm, while the stock is so depleted that it only rarely sends out a cast. Mr. Heddon, who carries this system yet further, and claims, in consequence, to make it invariably successful, shall speak for himself: "Let us suppose that colony No. 8 swarms June 15th. We mark upon the hive, 'O, June 15,' and on the hive in which we put the swarm, 'S, June 15.' When we hive the swarm (always on full sheets of wired foundation), we place it on the old stand, moving the old colony a few inches to the north (our hives front east), with its entrance turned northward, away from its swarm, about 45deg. As soon as the new colony is well at work, having their location well-marked (say, two days), we turn the old colony back parallel with the new one. Now both hives face east, sitting close beside each other. While each colony now recognises its own hive, they are, as regards all other colonies, on one and the same stand.

"The dates on the back end of the hives indicate that second swarming may be looked for about June 23. About two or three days before that date, and when the bees are well at work in the fields, we remove the old hive to a new location, in another part of the apiary. This depopulates the old colony, giving the force to the new, leaving too few bees in the old one for the young 'misses' to divide; and as they at once recognise this fact, they fight it out on the line of 'the survival of the fittest.'

"Remember that you are to remove the old hive to its final location when the workers are mostly in the field, and to move it carefully, so that very few

bees carried away with it will mark the new location. The old colony contains no very young brood, and very many newly-hatched bees, so that there will be no loss* of brood by this operation. In six† to ten days the old colony will have a fertile queen, as a rule, and become quite populous, when surplus receptacles may be adjusted to it. In my practice with this method, and the practice of many others who have used it, I am not aware of one instance of failure. The plan embraces the advantages of speed and certainty; there is no hunting for queens or queen-cells, or even opening the hives. It needs only to be properly executed to be appreciated." The general utility of this plan, and the reasons of its success, are too obvious to need comment. I cannot forbear, however, immediate reference to one point, of vital importance, lest the reader should imagine, as I believe erroneously, that Mr. Heddon seriously intends that, in the fighting of the queens, we get "the survival of the fittest." I shall hereafter, at length, endeavour to show that, since the most combative queen has the greater chance, queen-fighting is ever tending to select the most jealous and irritable—in itself a disadvantage—while the progeny of such queens are also likely to possess undesirable qualities. Let us never forget, that *the needs of the bee-keeper are not concurrent with those natural selections which are merely favourable to the queen herself*, and so man must

* Mr. Heddon means by chilling or neglect.

† This is certainly an under-statement; from eleven to fifteen days would be the average.

step in, and direct the production of queens, if he is to secure qualities which are to him, as a honey-producer, of the highest value.

But to return to our cast. A yet neater plan of preventing after-swarms, which is, unlike the foregoing, applicable to hives with fixed combs, as well as others, is possible if we have supernumerary queens. Giving a fertile mother to a colony that has cast a prime (or first) swarm will cause the queen-cells to be cut down, and so prevent further trouble. So ready are colonies, under these conditions, to accept a new queen, that even unimpregnated ones may be run in at the entrance (see "Queen Introduction"), within an hour or two of the swarm issuing, with perfect safety. The princesses, then very immature, are, as a result, destroyed.

In the busy season, the bee-keeper cannot do all that he would, and casts *will* occasionally occur, and, if properly treated, may be made into capital stocks, for, in some respects, they are even superior to prime swarms, which consist largely of old bees whose term of existence is rapidly running out; and so the 20,000 individuals, or thereabouts, that we hive, will have decreased, possibly, to 10,000, or even less, by the end of three weeks, when additions will commence from brood hatching. An after-swarm, on the contrary, contains a vast preponderance of young bees which were too frail, at the time of the first exodus, to take part in it; and these, having life before them, are not nearly so much thinned, at the expiration of the month which must elapse before new bees are added, as is the swarm at the less period above referred to. It will be remem-

bered here, that the young queen does not generally mate until from five to seven days after hiving, and that two days later she begins laying. On the twenty-first day next following, grey bees are gnawing out; and so the month is made up. This advantageous youthfulness in the cast is shared by the queen, who will reach her prime in the succeeding season. On the other side, the risk of the queen's marital flight must not be overlooked. A bird's bill, or a spider's web, or a mistake on her part at her return, may doom her colony, unless it be assisted by another queen, or ripe queen cell. Eggs are an unsuitable remedy, as they so tardily accomplish their purpose; and, unless prevented by foundation (see Chapter V.), during the whole period the bees are engaged in raising a new queen, drone-comb only will be built.

Casts often give the bee-keeper an opportunity of increasing his stock of queens, for each one of the latter may be made to head a nucleus at any spot we please, if we give comb (as described under "Nuclei") and a contingent of bees. Here her ladyship mates, to be afterwards disposed of as our purposes require. I have many times thus secured four or five queens from one cast. But hereafter we shall see reasons for supposing that this, although very convenient and, ordinarily, most useful, is not, after all, the most philosophical way of securing our queens.

Bees sometimes abscond because their stores have run out, and circumstances are desperate. Such have usually been called "hunger" or "vagabond" swarms. The method of preventing this annoyance and loss is obvious. After hiving the woebegone subjects of

misfortune or neglect, a comb of store and some unsealed brood should be at once given; then gentle feeding, continued with a generous hand until they have abundance, will restore contentment.

Through endeavouring to include all the difficulties likely to arise, the whole question may have been made to appear unduly complex to the beginner; but a little practice will show the mutual bearing of the numerous facts given, and enable the memory to easily carry them for use as required. The more advanced may suppose that I have been excessively cautious in recommending the novice to use gloves and veil in work commonly so easy as hiving swarms; but, be it remembered, my advice is to the "novice," whose remembrances of book directions are likely to get sadly scattered if he smart under an unwelcome sting, and then many may follow. In my opinion, the learner is far more likely to develop into a fearless adept if he start with a success, than if he begin by a failure and literally "taking pains." In the first case, his confidence grows, and his progress is secured, as his mind is free to observe, and make deductions; in the second, he neither learns nor achieves anything, while his timidity is increased. I have known, beside, of more than one of those who affect to sneer at a veil, making, now and again, more active use of their legs than their fingers. To the experienced, gloves are always a nuisance, and the veil very rarely needful; but to the learner working alone, I would say—any dressing that may be necessary to give calmness, is helpful. Under my own eye, in the grounds of the Natural History

Museum, with 200 persons present, having less than half-a-dozen veils between them, almost every operation of the apiary has been performed, with one or two stings, all told ; but I have been at hand to prevent wrong steps, or the results would have been far different.

Let us close with one reflection. How wondrous is this swarming instinct in the bee, with its attendant recognition of suitable conditions of population, wealth, and prospect—with its orderly execution, in correct sequence, of drone-production and queen-raising; and then, when all is ready, and the elements invite by their calmness, and the mysterious lot has been cast determining who shall go and who shall stay, the immediate change in the bearing of queen and every emigrant worker : the former, always hitherto hiding in the darkness, now coming forth to sport in the sunbeam ; the latter, that have striven with such devotion to fill the honey-cells, now becoming robbers in their own hive—for their old love is forgotten, and they turn their backs upon the house of their nativity, and the home for which they have lived and laboured, not even bestowing upon it a backward glance as they sail away. But even now beautiful unselfishness marks every movement, for they go to face difficulty, and toil in the founding of a new settlement, so that the mother and more favoured sisters may cause the race to multiply exceedingly.

CHAPTER V.

ARTIFICIAL AIDS TO COMB-BUILDING.

Ancient Methods—Comb Guides—Guides in Skeps—Guide Bars—Plain Guide-maker—Wax Smelter—Foundation: its Importance—Mehring's Invention—Wax Sheet — Cheshire Foundation — Foundation Machines — Fixing — Split Top Bar — Hooker's Stretcher—Lee's Dovetail Joint—Carr's Adjustable Ends—Sagging: Methods of Preventing—Wired Foundation — Cheshire Fixers — Wired Frames—Embedders — Cast Foundation — Thickness for Foundation—Mathematics of the Question—Variation in Size of Cells—Abnormal Comb—The First and Second Row of Cells—Singular Adaptation.

THE movable comb system demands ability to direct and control the position given by the bees to their slabs of cells. The most obvious, and probably the most ancient, method of securing this necessary power was that followed, at the Eastern end of the Mediterranean, many centuries since, and adopted by Huber, who fixed the straightest pieces of comb at command against the under side of the top bars of his leaf hive (page 42). Up to our own day, this system, somewhat modified, is used largely on

the Continent, and although, perhaps, we should regard it as a little primitive, it may, perchance, be of service, and so justifies a few lines of explanation. Comb—preferably that made tough by breeding, and which contains no honey—is first cut into strips of three or four cells deep. The frames to be operated upon being inverted, the under side of each top bar is painted well with wax, to which a little resin may, with advantage, be added. A heated iron (the homely poker answering well) brings again the cement to the liquid condition, when the comb is pressed into place, care being taken that the midrib lies along the centre of the wood. The comb strips can, if necessary, be flattened by rubbing with a heated laundry iron the surface which is to be fixed. Methylated spirit, applied to a thin knife, as before stated, obviates all ragging, and makes the cutting of even tender comb so easy that scarcely a cell wall need be broken.

Even skeps are not beyond the reach of the refinement of straight combs. Dark pencil lines $1\frac{1}{2}$in. bare apart give the position for the guides, which may be fixed by painting the part each is to occupy three or four times with wax, and then, while the latter is still liquid, pressing the guide on to it, and holding steadily till the work is secure. Wax so used should be heated in an arrangement after the form of the carpenter's glue-pot, to prevent burning, while boiling water imparts a desirable temperature for working. Using glue for comb-fixing is a French fashion. The glue is certainly easily manipulated, and the bees quickly make all solid, after their own taste. The

guides completed, a stick may be run through the skep, about 4in. from the bottom rim, and at right angles to the guides, when the combs, as built, will be fastened and saved from lateral sway. Skeps so prepared are capital travellers, and, being abnormally regular, are most useful for demonstrations of driving in bee-tent work.

The knowledge that bees extend their comb downwards indefinitely, and that the cells above determine the position of those below—the fact to which the before-going method owes its success—was followed by the observation that the midrib precedes the cell, and that the comb always grows not only downwards, but from the centre to the surface, and hence two, perhaps more refined, plans for directing comb-building were soon scored as successes. The first consisted in giving prominence to the line which the midrib was intended to follow; Mr. Woodbury, *e.g.*, adding a central projecting slip beneath his top bar, while he rounded off the lower angles of the latter, so that the clinging bees should place their "foundations" on the central line, so temptingly pushed before the attention of the wax-workers. Langstroth and others, in like manner, achieved the same result by setting a top bar, triangular or square in cross-section, with its lower faces at 45deg. to the horizontal (Fig. 11); Mr. Woodbury's idea being, in turn, simplified by cutting a saw-kerf into the top bar (D, Fig. 44), and placing within a wooden slip (*ws*), which was often made additionally attractive by being painted with wax.

The second process, instead of striving to coax the bees to place their midrib as desired, actually manu-

factured the latter *in situ*, which they must either accept as part of their structure, or destroy at some cost of labour. The plain wax guides to which I refer, although not so well liked by the bees, are, in some respects, quite equal to narrow strips of foundation, now generally used; they certainly are less liable to fracture, and can be much more quickly set in position, and in the following manner: Pre-

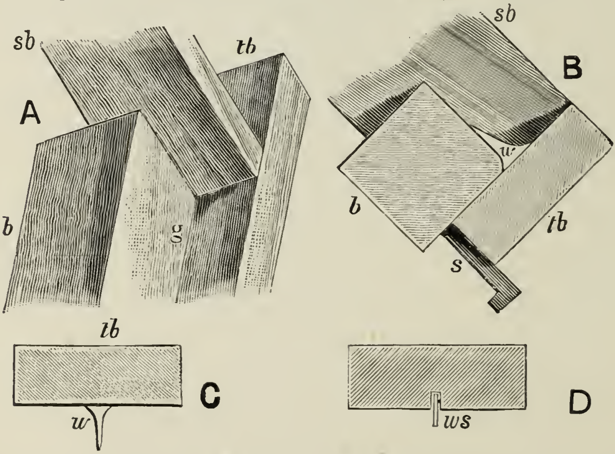


FIG. 44.—SIMPLE GUIDE MAKER (Full size).

A—*tb*, Top Bar of Frame; *sb*, Side Bar; *b*, Block to make Guide; *g*, Gutter to receive Wax. B and C, Sections—*w*, Wax Guide; *s*, Stop; other Letterings as before. D—Top Bar, with *ws*, Wood-strip Guide.

pare, by carefully planing, a slip of soft wood (*b*, A and B, Fig. 44), free from knots, about $\frac{3}{4}$in. thick, and of the length between the sides of the frames to be waxed, and drive into it two brads (*s*, B), at bare $\frac{7}{16}$in. from its edge (or bare half the width of the frame); thoroughly soak this slip in water, and it is ready for use. Place it upon the under side of the top bar (*tb*), allowing the brads to act as stops; it will then

cover slightly less than half the width of the bar. The wax may be painted on with a brush, but it is far better to hold the top bar against the ball of the left thumb, by pressing upon *b* with the fingers, and so inclining the frame that a gutter (*g*) is formed, one end of which is much higher than the other. At the top part of the gutter, now pour in a few drops of clear wax, which should be many degrees above its melting point, and will run from end to end, quickly or slowly, as the decline is increased or decreased. The wax, setting, will adhere to the bar with astonishing tenacity, while the slip may be removed at once, since to it no attachment has taken place, the wax standing as a thin wall (*w*).

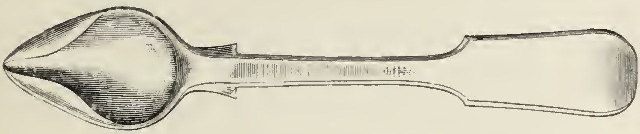


FIG. 45.—SPOON FOR DROPPING MOLTEN WAX.

The latter is made both more solid, and more symmetrical, by a slight chamfering of the slip (*b*). It will be modelled by the bees into a midrib of the usual pattern, while time will be saved, since operations will be started immediately at two or three points in the length of the guide, where, naturally, one alone would have been taken, and less wax need be secreted. The plain guides should not, however, be made more than ¼in. deep, or they will considerably puzzle the poor little sculptors, whose pittings will then frequently be misplaced, so that corrections of their first sketch will hinder more time than has been saved. Frames so furnished, placed between straight combs, and

given to casts, will be filled out with beautiful and most useful slabs of worker-cells only.

The application of the molten beeswax is much facilitated by a simple device readily made out of an ordinary spoon, by turning up the sides of the bowl, as indicated in Fig. 45, so as to form a narrow trough with a pointed end, which can be brought close to the spot where the wax should be placed.

Those who have many stocks will find an apparatus commonly called a "wax-smelter" of frequent service,

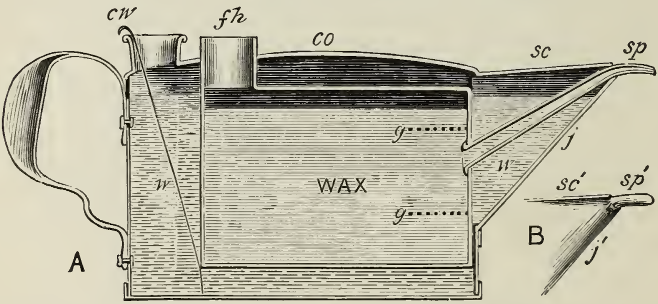


FIG. 46.—CHESHIRE'S WAX-SMELTER—SECTION (Scale, ½).
A, Smelter; *w*, *w*, Water-chamber; *co*, Cover; *fh*, Feedhole for Wax; *sp*, Spout; *sc*, Spout-cover; *j*, Jacket to Spout; *g*, Guard; *cw*, Clearing Wire. B, Jacket on Spout *in situ*—Letterings as before.

indeed, indispensable, if methods are followed which require the use of liquid wax. The construction given in the guide-books is possessed of very grave faults, which I have remedied in the smelter seen in section, Fig. 46. An oval form, *in plan*, is, perhaps, best both for inner and outer chambers, while the spout-jacket (*j*) is shaped like the bow of a ship. In making it, the wax-chamber is separately completed, and the water-box made entire, save that the covers (*co*, *sc*) are not added. The wax-chamber

is next put into position, and its spout tacked with solder to the end of the jacket. The cover (*co*), perforated to pass the feedhole (*fh*), is now, with *sc*, soldered to the water-chamber and around the wax feedhole, when all is complete. The advantages are these: In the old form, the amount of water contained could not be discovered, and hence boiling dry, and consequent unsoldering, was of frequent occurrence, when the structure was such that repair was almost impossible; here, the water is in full view, and if, by any chance, repairs are needed, unsoldering the covers and the junction between spout and jacket liberates the wax-chamber, and makes the whole business as simple as any tinker could desire. The spout is more convenient, since no angle exists to prevent it being brought up close to its work, while the water circulates freely round it, saving the wax from chilling. A clearing wire (*cw*) is kept in the water-chamber, to apply if any substance should clog the narrow exit. The wax cannot run from the feedhole (*fh*), and a ring of perforated metal (*g*, *g*) permits of the use of the smelter so soon as the contained water reaches the boiling point. A considerable block of solid wax is long melting, and the old model will not work satisfactorily till this operation is complete; here, so soon as the water is of the required temperature, the molten wax will flow freely, since the perforated ring holds the unmelted part of the block, in which it is embedded, away from the spout, in flowing through which the wax acquires the heat of the surrounding water. Those who have been troubled by old defects will best appreciate these

alterations. Whatever plan be adopted for heating wax, care should always be exercised in preventing burning.

The fact just now enunciated, that bees will accept and utilise a wax midrib, prepares the way for the description of a device which was the earliest to strive to take the fullest advantage of all it implies. The conception that complete artificial midribs might be adopted was a grand one, and, although failure attended the first experiments, failure but pointed the way to a success finally so complete and important that its effect on apiculture is already only second to that of the introduction of the movable-comb system itself. Great thoughts do not always, in their inception, show their importance, and so history often fails where we most desire her teachings; but it would appear that one Kretchmer, a German, about 1843, dipped tracing-linen into molten wax, and afterwards passed it between rollers to give it the form of the midrib. The bees would, probably, start their combs upon the lines laid down for them, but, reaching the fibres of the linen, they would, in their endeavours to tease them out, involve the handiwork of their human helper and director in hopeless ruin. Another German (Mehring), fourteen years later, contrived wooden moulds, in which the wax received the desired shape; but these gave way to others for casting type-metal plates (Fig. 47), upon which the facsimile of the rhombic bases of perfect cells were so accurately formed that the two plates in my possession, put face to face, fit into one another without a traceable loss of contact in any part. These marvels

of exact workmanship were made about 12in. by 7in., and it is clear that, if a thin sheet of wax could be sufficiently pressed between them, it would receive the absolute figure given by bees to their midrib; in other words, it would resemble comb with the cell walls removed.

Let us now devote our attention to the manner in which these wax sheets were, and are, prepared, for they now form the base upon which our modern foundation is manufactured.

The first need is a dipping-vessel necessarily some-

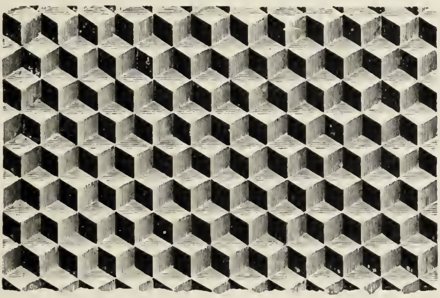


FIG. 47.—PORTION OF A TYPE-METAL PLATE—*i.e.*, FORM OF COMB MIDRIB (Five cells to the inch).

what greater in depth and width than the sheets to be made, and this should be fitted into a second, containing water, so that burning the wax is impossible, as by no carelessness can it then be raised above 212deg. Fahr. Some prefer the dipping-can to carry a perpendicular diaphragm of perforated metal, on one side of which is added, from time to time, fresh wax, to keep up the quantity. The wax needs only to be a little above its melting point (150deg.). Dipping-boards are prepared of seasoned, knotless

pine, from $\frac{1}{4}$in. to $\frac{3}{8}$in. thick, and made very smooth. These should be, when dry, the width required for the sheet. Soak the boards thoroughly, when they will swell as much as the sheets will shrink in cooling. Dip one of these soaked boards into cold water, shake off all excess, and then plunge more than half-way into the wax. Raise it again, when it brings up a layer of wax, covering both its sides. Hold perpendicularly till the wax ceases dripping. Plunge now into cold water, reverse the end, and proceed as before. Twice dipping at each end will give a sheet thick enough for brood-combs ; one dip suffices for sheets to be used in sections. As the ends of the boards are submerged longest, and also as the wax has a disposition to run from the middle when the board is uplifted, the layer at the end of the board is thicker than the rest. This defect is remedied by dipping more than half-way, so that the central parts get four layers to the two of the ends. In cooling and contracting, the sheet partly strips itself from the wet wood, from which it can be separated with great facility. Adhesion, caused by imperfect soaking, will spoil the boards : if the result of roughness through wear, the remedy is drying and careful rubbing with fine glass-paper. Should the wax used be too hot, the excessive contraction will sometimes cause the sheets to actually split ; and incipient cracks, passing unnoticed, will be likely to wreck the sheets when given as foundation to the bees.

Foundation is now sold so cheaply that none would care, perhaps, to make wax sheet; but the

amateur would succeed were he to use a layer of one or two inches only of wax over water, in a sufficiently deep vessel. More dips and more cold water are required, but the resulting sheets are more even in thickness, and may be converted, without a foundation machine, into a practically useful foundation, as hereafter explained.

Let us return to the type-metal plates and the manner of using them. After lying in a bath of soapy water, at 120deg., to soften and prevent sticking, the wax sheets were placed between the plates, which were generally backed by a pair of strong, hinged boards,

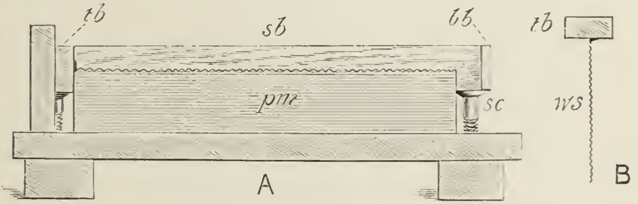


FIG. 48.—CHESHIRE'S PLASTER MOULD AND BLOCK FOR MAKING ARTIFICIAL MIDRIB, IN SECTION (Scale, ¼).

A, Midrib *in situ*—*tb*, Top Bar of Frame ; *sb*, Side Bar ; *bb*, Bottom Bar ; *sc*, Screw ; *pm*, Plaster Mould. B, Top Bar Carrying Midrib—Letterings as before.

used like lemon-squeezers, when a fairly sharp impression was produced. The plans for fixing embossed sheet into frames apply equally to modern foundation, and so need now receive no attention. All attempts at using these sheets of full size failed. No sooner were they warmed by the bees than their stamped pittings became shallower, and the sheets stretched. Practice showed that guides 1½in. or 2in. deep could not with advantage be exceeded, and so I started a process which must not be altogether omitted, as it enabled me to use full sheets with perfect success

some time before machine foundation had appeared amongst us.

Moulds (*pm*, A, Fig. 48) were made, in plaster of Paris, upon the type-metal plate before described; when these were properly dried, their edges were planed true. For use, one was soaked in water, and placed upon a block having four adjusting screws (*sc*), upon which rested, horizontally, a frame, so that the middle of its top bar (*tb*) was slightly higher than the level of the mould. Molten wax was now painted against the top bar and over the plaster, where the chill immediately set a skin of wax, which, of course, did not adhere, while it completely incorporated itself with the wood. The top bar, raised, brought with it a firmly-attached sheet in correct position, and as straight as an arrow. A dabbing motion with the brush produced the best impression, which, after a little practice, I was able to make nearly perfect upon the upper side: that below was, of course, completely so. When these sheets were given to the bees, the results were almost incredible; but they made evident what had before escaped me, that the lozenges of the metal plate were rather too small, and so I determined to utilise natural comb. Old straight pieces were selected, and, with many devices, which it would be tedious to recount, the cell walls were shaved down, when a cast was taken, to replace the one of Fig. 48. A swarm was provided with ten sheets made from these, and, in sixty-two hours after hiving, I was charmed to find ten combs absolutely complete, without a drone-cell, and all as flat as a table. In many instances, these

sheets were converted into combs in twenty hours, besides having many eggs laid in them.

It is the fashion to prefer worker-comb to drone for supers and sections. It is more than a mere fashion, as we shall note when treating of honey; but it cannot be denied that drone-sized cells store more in proportion to the amount of wax required, and demand, in proportion to their area, less labour in their construction by the bees, who in them deposit no pollen; and so I determined to be able to secure drone-celled midribs for my supers. Carving at the old comb had proved that the lozenges all disappear. I have now shown that the excrement of the larvæ fills up the corners (page 22, Vol. I.), and that all cells, as constructed, are at first curvilinear in their concave bases; these and other reasons convinced me then, and still do so, that cup-like concavities are theoretically correct for artificial midribs. Following this line, I procured the extremely large shot called SSG, drove them through a $\frac{1}{4}$in. hollow punch, arranged them in due order in a tray, heated them, and filled in their interstices with paraffin wax, then took a cast from them in plaster, soaked this cast in paraffin, and took another from it, which, for my new purpose, replaced *pm*, Fig. 48. The sheets were brush-made, as before; the top bars of the supers then in use simply taking the position before given to the top bar of the frame.

These drone midribs worked to my fullest satisfaction. One instance of their performance will suffice. I fully furnished three Woodbury supers, each 6in. deep, and exhibited the result at the Alexandra Palace. The whole of the combs (built

without separators) were so flat that no point existed in which a newspaper could not be read between them through their whole depth of 18in.—a regularity which, I venture to believe, has never been excelled in any one instance to the present hour. But a fact of some importance lies before us, to receive comment hereafter. These sheets did not stretch, and most severe trials, through which they were passed in Pettigrew skeps, did not break them. Why were they, when of equal weight, more capable of sustaining strain than machine-made foundation of the present day?

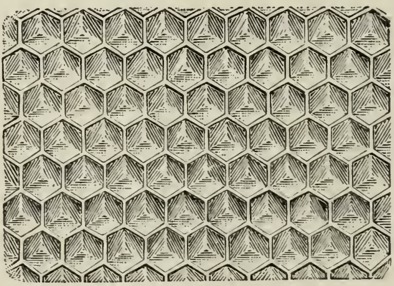


FIG. 49.—ROLLER-PRESSED FOUNDATION.

With all these good points, these waxen sheets had two defects, the first remediable, the second fatal. They were more or less imperfect on the side next the brush: this I obviated by a process immediately after obsoleted by the introduction of cast foundation. But they were inherently messy, and Mr. Root (whom I should imagine to be amongst the neatest of men) gave such an account of the dropping wax when he tried his hand, that I felt almost vain of my tidiness, while it was evident that some-

thing different was needed to settle the problem. And, ere long, dainty pieces of foundation, modelled to perfection in white wax, by being pressed through a roller machine like a patent mangle, by which they had acquired almost a metallic lustre,

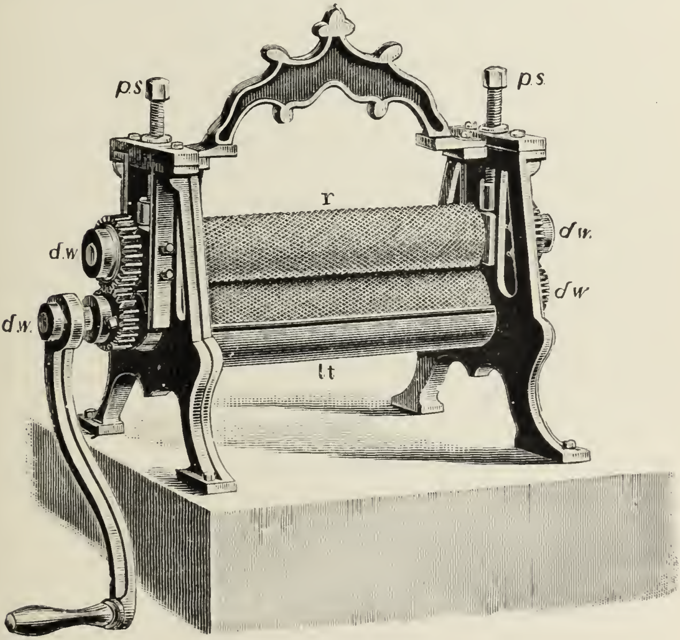


FIG. 50.—FOUNDATION MACHINE (Scale, $\frac{1}{5}$).

r, Rolls ; *ps*, *ps*, Pressure-screws ; *dw*, *dw*, Driving Wheels ; *lt*, Lubricating-trough.

found their way from across the Atlantic. This material was sent out by "John Long," but was made by a machine invented by Weiss, a German. The rhomboidal bases were exact, and the cell walls partly raised, as we find them in Fig. 49. The

rollers being only 6in. long, the sheets formed were of restricted dimensions ; but American enterpise saw "there was money in it," and Mr. A. I. Root, whose painting in wax had produced such an unsightly picture, quickly had machines ready for the market, and our friend Mr. Raitt, who became, to use his own words, "the happy possessor of a machine, the first of the kind on this side of the Atlantic," was soon busy turning out foundation of delightful finish and great tenacity. Many alterations and some improvements have followed, but even yet no pattern seems to stand better than that made by the earlier machines in which the rhomboids are kept at the pitch given to them under pressure by the side walls standing between them.

The sheets, having been made on dipping-boards, are ready to be passed between the rolls, which can be adjusted by the pressure-screws (*ps, ps*) to the thickness of foundation required—a point which should be carefully studied at the time of dipping. The sheets are somewhat extended in their passage, which, for reasons hereafter given, may break down the molecular arrangement of the wax, and diminish its cohesion. The sheets would stick hopelessly to the rolls unless a "lubricator" were employed. This is added in the lubricating-trough (*lt*). Some use soapy water. Mr. A. I. Root recommends thin paste, made of cheap starch, as the very best material with which he is acquainted. From experiment, I believe that infusion of quilla bark, might, with great advantage, replace the soapy water at least. Its action in preventing sticking is simply perfection. The altera-

tions just now referred to have mainly applied to the particular cut of the rolls, modifying somewhat the form of surface given to each cell base. Amongst a considerable number of distinct makes, one or two only need be mentioned.

The Van Deuzen mill produces what is known as flat-bottomed foundation, in which the rhomboidal bases are dispensed with altogether; cell walls alone being engraved on the rolls. This mill is usually made to turn out thin white wax foundation for sections, which has great beauty of finish, but is thought to be not quite so acceptable to the bees as the more common pattern. An interesting and ingenious variation in the form of the rolls has been originated by Mr. Pelham. A reference to the accompanying figures will enable us to understand his system. Wax sheets, of course, run through these machines, not from above downwards, but in the direction of their length. If we cut a piece of foundation (A, Fig. 51) into strips (which would be horizontal as the foundation hangs in a frame), taking care that the cut passes through the centre of each alternate line of cells, we obtain strips precisely like to each other; and although the right and left (*r* and *l*, A, Fig. 51) edges of each strip are dissimilar, still the right or the left edge of any strip is like to the corresponding edge of every other. If, therefore, we could multiply any one of these strips, and place the results side by side, we should make up the form of a complete midrib. Modelling a matrix for one of these strips on the edge of a ring (*ri*, B), taking care that the pattern returns into itself,

and then multiplying the said ring, we are in a position to build up a roll at much less cost than if all had to be independently produced.

Mr. Pelham carries this principle further, and, in so doing, makes a virtue of necessity, in increasing the width of the cell base, while he takes one or

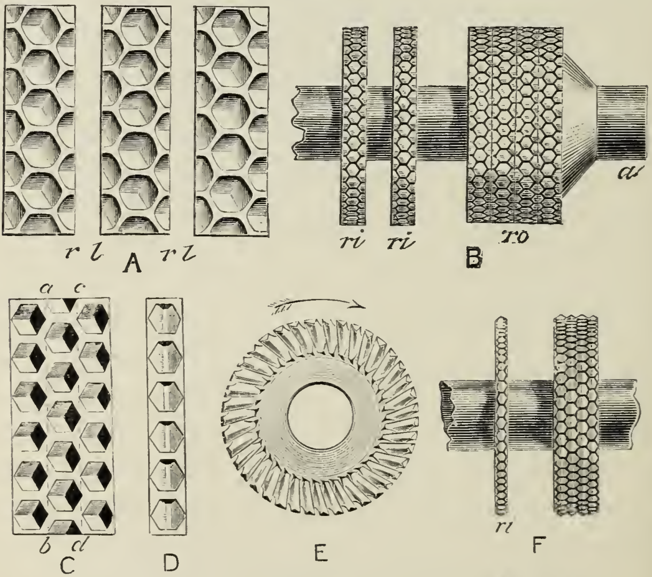


FIG. 51.—DETAILS OF SECTION-MADE FOUNDATION MACHINE.

A, Comb in Strips (natural size). B, Section-made Roll (scale, ⅓)—*a*, Axis; *ri*, *ri*, Rings; *ro*, Roll, partly completed. C, Plan of Pelham Roll. D, Portion of Matrix for Edge of Ring (actual size). E, Side View of Ring, carrying Dies. F, Portion of Axis, carrying four Rings united and one separate.

two liberties with the form of the midrib, which secure mechanical advantages without appearing to appreciably damage its suitability. If we examine the strips (A), we find it impossible to retain the five complete hexagons each carries without taking

in parts of others; but if we reduce these hexagons sufficiently, without altering their relative positions and distances from centre to centre, as at C, we may draw lines *a b* and *c d*, and so separate the hexagons without breaking into the outline of neighbouring ones. Mr. Pelham, perceiving this, so widens his cell wall that these dividing lines *can* be drawn as we have them in the figure. The resulting hexagons, in one file only, have their matrix prepared on the edges of rings, of which the side view of one is seen at E. When they are fitted together, the centre of each hexagon is necessarily in line with the space between two in the ring adjacent on each side, as at F. The rhomboidal form of base is not adhered to, the cell being merely furrowed down the middle, as at D, in obedience to the wedge-like form given to each die, well seen at the edge of the ring (*ri′*); nor are the impressing dies set radially (E), the latter innovation aiding them in clearing the deep impressions made. Excellent as this form of foundation is admitted to be, I have noticed in it occasionally, and in some others—notably the English flat-bottomed—frequently, that the cells of the two sides are not properly superposed. This defect is visible immediately if the foundation be held up to the light. When it occurs, the building-out is often confused, with some small, useless cells, and others of drone size.

There are many methods of fixing foundation, that by molten wax being the most usual, while it is applicable to every form of frame. I employ a board (Fig. 52) rather thicker than half the width of

the frame, while its length and breadth are such that the latter freely passes over it. Battens (*b*, *b*), 2in. longer than the board, are fixed flush with its edges. Screws (*s*, *s*) are added, and so regulated that, when the frame is passed over the board, the sheet of foundation, put into place, may have its upper edge lying along the centre of the top bar. The whole is taken into the left hand, the board lying over the left lower arm. The thumb now grasps the top batten, while the fingers embrace the top bar and press it into position against the board. The foundation, which must have its upper edge cut true, is, if necessary, pushed against the top bar, and has

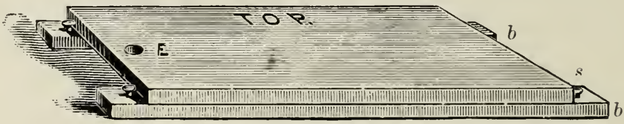


FIG. 52.—BOARD FOR FIXING FOUNDATION (Scale, $\frac{1}{6}$).
b, *b*, Battens ; *s*, *s*, Regulating Screws.

such an inclination given to it that the wax poured from the spoon (Fig. 45) or the smelter (Fig. 46) may run down between it and the wood which is to support it, and, in so doing, weld the two firmly together. The smelter is now returned to the lamp or hot plate and a moment given to the wax to set, when, by a turn of the wrist, the board is brought to the perpendicular; the right hand now removing the frame, holding it plumb, and placing it in a hive or rack. A little practice will enable this operation to be performed with great quickness, and, if the plan recommended be followed, "breaking down" will be unknown. If the wax be too hot, it will melt the

foundation; if too cool, it will not adhere. The former error is hardly possible in chilly weather. Some recommend that the sheet be waxed on both sides, from which I beg to dissent. The line of molten wax partly conceals the form of the cells lying beneath it, and hinders the work of extending the comb at this point. Keeping one side perfectly clear secures an immediate building-out of the walls of the uppermost cells on that side, and so prevents the falling of combs, of which complaints are sometimes heard. Dr. Bartrum, some years since, asked if I thought this one-side fixing really strong enough, referring to a Stewarton that I had supplied throughout with foundation. My answer consisted in lifting and carrying the inverted Stewarton body-box by the foundation attached to its middle bar.

To avoid the need of molten wax, some bring the circular saw through the middle of the top bar, dividing the latter up to the ears, in order that the edge of the foundation may be inserted. The operation is, however, not an easy one, and is unfair to the foundation in two ways—first, in the struggle to get it into place, a partial fracture is likely to be produced, to result in complete breakdown when the foundation is warmed in the hive, and called upon to support the weight of the adherent bees; and, second, the insertion is not so easily accomplished near the ends of the saw-cut as in its middle, inducing, unless great care is exercised, buckling, which will develop most annoyingly whilst the foundation is being drawn out in the hive. Mr. Hooker suggests opening the saw-cut by a wedge, and then

driving into the upper side of the top bar a steel appliance resembling a two-pronged fork, terminated by parallel knife edges instead of points. The wedge being withdrawn, the tool holds open the cleft, permitting the more convenient insertion of the foundation, but the before-mentioned difficulties remain. Others reduce these by half dividing the top bar by a second cut run transversely into the extremity of the first, or end the trouble by a third cut, completely separating half of so much of the top bar as stands between the sides. After inserting

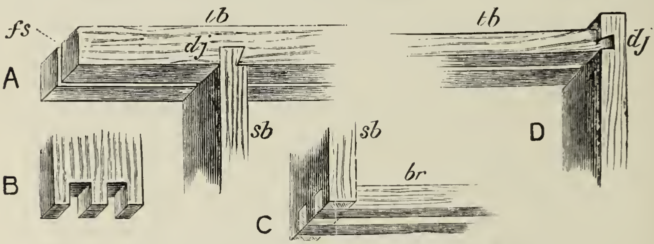


Fig. 53.—Details of Lee's Dovetail-jointed Frames (Scale, ½).

A, Part of Standard Frame—*tb*, Top Bar; *sb*, Side Bar; *dj*, Dovetail Joint; *fs*, Foundation Space. B, Lower End of Side Bar. C, Ditto with *br*, Double Bottom Rail. D, Upper Corner of Standing Invertible Frame—Letterings as before.

the foundation, the parts are joined up again by nailing. These devices all weaken the frame, and require a far greater expenditure of time than waxing, to which they are, in my opinion, unequal.

Mr. James Lee, long known to bee-keepers as a most accomplished manipulator of the saw-bench, has just invented a frame presenting so many good points that it must become a favourite. It is introduced here because of the extreme facility and security with which foundation can be inserted in it; but its structure must be examined in order that it may be

understood. The side bar (*sb*, A, Fig. 53) has a peculiar dovetail worked on its upper end, which fits into a corresponding hollow cut transversely into the two pieces which, standing parallel to each other, form the top bar. It is intended to send out these frames in the flat, the foundation being inserted during the building-up. The ingenious frame-block (Fig. 54) makes this operation quite delightful, and

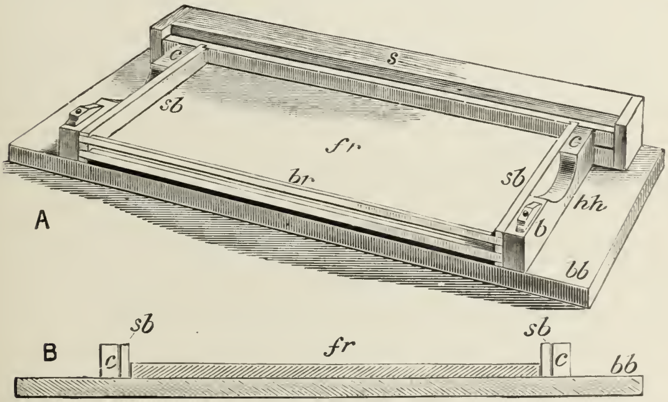


FIG. 54.—LEE'S BLOCK FOR HIS STANDARD DOVETAILED FRAME (Scale, ⅛).

A, Block *in situ*—*s*, Stop; *c*, *c*, Cheeks; *bb*, Bottom Board; *fr*, Foundation Rest; *b*, Button; *hh*, Hand Hollow; *sb*, *sb*, Side Bars of Frame; *br*, Bottom Rails. B, Longitudinal Section through Block—Letterings as before.

even to the novice who may have no mechanical ability it is perfectly easy. The half top bar is first dropped into position between the foundation rest (*fr*) and the stop (*s*). The side bars are next added, being slipped between the cheeks (*c*, *c*), and the foundation rest, as seen in the section, when their dovetails are driven home, firmly connecting them with the half top bar; the buttons (*b*) being turned so as to keep the former firm until completion.

The lower bottom rail follows, being inserted (preferably with a touch of glue) into the side-bar notches. The foundation is now placed in position, its upper edge covering the half top bar, the upper face of which is exactly level with the face of the foundation rest. The second half top bar is next pressed on, so as to grip the foundation. To assist in this, the marked and proximate faces of the two pieces are a little convex. Adding the second bottom rail completes the whole, and lifting the block to the perpendicular, turning the buttons, and removing the frame, with its fixed sheet of foundation, is the work of a moment; and I find, after a number of trials, that the whole operation of building-up and fixing foundation occupies about half a minute.

Two practically essential questions at once suggest themselves: Is the foundation firmly held? and is the frame thus pushed together sufficiently solid for work? The result of experiment is far more to the purpose than a statement of opinion. Two sheets were tested. The first remained unmoved till the strain reached 19lb.; it then broke, part being left in the cleft: the second, at 15lb. parted at the side, some portion being withdrawn, and some left in the cleft. The weight was distributed by clamping the sheet. The rigidity of the frame is remarkable, and its accurate make prevents any trace of winding. The dovetail, also, has great holding power. The lighter, invertible standing frames (D, Fig. 53) were more easily tested than the Standards, and here the dovetails bore an average strain of 52lb. before the side bar was broken from its

place. Mr. Lee's idea is to use foundation so deep that its lower edge may hang loosely between the bottom rails, and thus be kept perfectly straight. Whether this be practicable will much depend on circumstances to be presently considered. He has not limited his dovetail joint to frames, but has applied it to hive bodies and sections, all of which may be sent out in the flat, and put together without nails, in a manner requiring no further explanation than that furnished by Fig. 55.

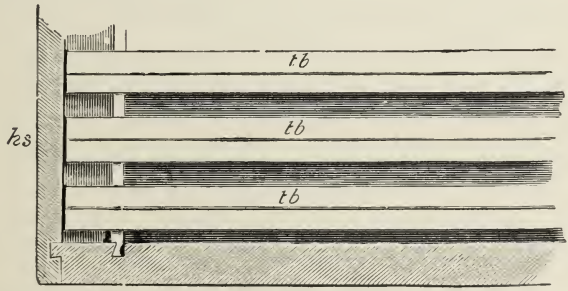


FIG. 55.—CORNER OF HIVE BODY, WITH LEE'S CONTINUOUS DOVETAIL JOINT (Scale, ¼).
tb, tb, Top Bars; *hs,* Hive Side.

The poet but expresses a prosaic truth of this mundane state in singing—

> "He that expects a perfect thing to see,
> Expects what ne'er was, nor is, nor e'er shall be";

and foundation, with its all beauty (for a sheet from the hands of an expert maker cannot but excite admiration), still has a fault—a liability to stretch when warmed by the heat, and pulled by the weight, of the bees. Purity of material, skilful manufacture, and careful management, are all essential if we would prevent this fault from making itself disagreeably

evident. Adulterants are largely used by wax-refiners, and amongst these hard paraffin occupies a conspicuous place. Bees accept the mixture, and in cool weather beautiful combs* appear; but the melting point (about 150deg. for wax) is lowered by the fraud, and the tenacity at 80deg. and upwards so exceedingly reduced, that the ardour of a July sun will probably involve the bees and their works in hopeless ruin. The methods which unmask this cruel cheat will come before us when treating of adulteration.

Even with a genuine article, the maker must know his art: Mr. Raitt, speaking from long experience, says:† "Air bubbles that get lifted with the dipping-board, and then run down its surface before the wax cools, leave behind them a thin track, which becomes a weak part in the sheet. The edges of the sheets, unless well pared, are also thinner than the rest, and may lead to a fracture close to the top bar. Those that are right are uniform in texture and thickness, and show no flaws. If the sheets are dipped too thin, they do not contain enough wax to fill the grooves in the rollers that form the cell walls, and an important element of strength is then lost. The midrib may be excessively thin, and yet

* Mr. A. I. Root, about ten years since, claimed the successful use of a mixture of paraffin and Burgundy pitch as a substitute for wax for comb foundation; but he soon had to confess that he had shouted "Eureka" prematurely, the heat of summer converting the satisfaction of the ingenious inventor into annoyance for himself and his bees. It is interesting to note, in this connection, that paraffin was first produced, in the laboratory of the chemist, by distilling beeswax with caustic lime. There is a long series of paraffins, gaseous, liquid, and solid; those specimens having the highest melting point are too hard, too brittle, and too expensive, to be used as adulterants.

† "Bee-keepers' Record," Vol. iv., page 49.

no harm result, if the side walls be fully raised. A glance along the surface of the sheet, between the eye and the light, will reveal any such deficiency. We find we can make perfect sheets on the original Root machine that weigh seven to the pound, Standard size, though on the later machine only five or six can be got."

Having secured the best that a conscientious and able maker can supply, caution is still needed. In hot weather, without some device to prevent sagging, foundation cannot safely be given to stocks, even in single sheets, without great risk of undue stretching; but the careful bee-keeper will either adopt such a device, giving him ability to get foundation converted into comb under any likely conditions, or he will contrive to have his foundation built (drawn out) in the spring. Under this plan, combs removed from the stocks in preparation for wintering, instead of being returned in the opening months of the season, as the colonies increase in numbers, are held in reserve for swarms, extraction, or condemned bees. The foundation may, in this case, extend to within ½in. or a little more from the bottom rail, and, if we please, reach to the sides of the frame at top, and clear them by ¼in. at the bottom; then worker-cells will be secured, filling the frame, yet giving the bees the chance of piecing on just a very few of the larger size in the corners. Foundation 3in. or 4in. in depth loses its main value, as the bees, especially if prosperous, persist in filling the unoccupied part of the frame with drone-cells.

My own experience in hiving swarms upon unaided full sheets is such that my advice would be, Don't.

Stretching is all but inevitable, and a breakdown not infrequent. In attempting this, which some (whose cautiousness is less than my own) recommend, fix the foundation carefully, and keep the hive in the shade until the evening. Then, without jar, place it in true position, so that the sheets hang plumb. If unable to keep the hive out of the sun, cover it with towelling or sacking, occasionally thoroughly soaking the latter with water. Now introduce the bees, by throwing down in front, as explained in the last chapter, allowing them only the usual doorway by which to enter, so that they may not suddenly collect in heavy masses upon any of the sheets. Have only a single thin covering over the tops of the frames, holding down its edges by wooden slips, and place, if possible, the frames at not more than $1\frac{1}{4}$in. from centre to centre. This is most important: the bees in ascending hang closely on to the sheets, and to one another; and the larger the interspace, the greater is the weight each sheet must sustain, and the smaller the amount of surface upon which operations will be commenced. The risk is reduced immensely if foundation be alternated with comb, when the interspace should still be small.

Those using metal ends here labour under a disadvantage I have previously pointed out. Mr. Broughton Carr, to remedy this, has just given us a handy appliance, which will be hailed by many as a felt want. It is a metal end, allowing of the desired variation in frame distance, with a very inconsiderable amount of labour. The triangular strut (Fig. 21) is not provided, the inventor well arguing

that this is a valueless addition when the frame ends themselves keep the lateral spacing. They are struck up from ordinary tin plate, and grasp the lug by their own elasticity. When it is desired to reduce the interspace, it is only necessary to draw back every alternate one, as at A; and this can be accomplished without removing the frame from the hive. The retention of the Standard top bar necessitates the prolongation of the metal to *e*, where it is doubled round, so as to meet the face of the

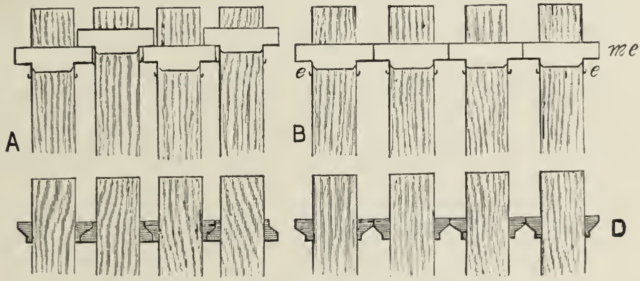


FIG. 56.—ADJUSTABLE METAL ENDS (Scale, $\frac{1}{4}$).
A, Carr's, Set for Narrow Spacing. B, Ditto for Wide Spacing—*me*, Metal Ends. C and D, Another Form suggested by Author.

next "end," and preserve the exact distance of $1\frac{6}{20}$in. from centre to centre. I have often thought that the form suggested by C and D, made in type-metal, would answer the purpose of many. The wide sides of the "ends" being made $1\frac{9}{20}$in., will make this the distance of frames from centre to centre. Under the arrangement D, the opposite side being $1\frac{3}{20}$in., the turning of every alternate "end" makes the spacing the mean between the two—*i.e.*, $1\frac{6}{20}$in., as at C. This form has inconveniently narrow, abutting faces, and the disadvantage of requiring to be pulled off and

put on again; but it has the good point of being capable of spacing to every distance intermediate between the widest and narrowest, by slipping the alternate ends back, much or little, as may be required. Propolis would then, however, in most localities, do its evil work.

The extreme importance of being able to use foundation at all normal temperatures, and with stocks or swarms indifferently, stimulated the search for methods which should completely overmaster the besetting weakness adverted to (page 195), and the Van Deusen Nillis wired foundation, with flat bottoms to the cells, first promised a satisfactory solution of the difficulty. At intervals of an inch, thin iron wires were embedded, taking the perpendicular as the foundation hung in the frame, and so holding the sheet that the disposition to stretch downwards, under the weight of the builders, was entirely obviated. Every cell of the resulting combs was mathematically symmetrical; but careful experiment showed that the grubs maturing in those through whose bases the wires ran, frequently died, and I had cases of long lines of dead larvæ, pointing out unmistakably the path the wire took. This fatality appears to have been due to neglecting to use wire properly protected by tinning. The reason why the flat bottom was chosen is obvious. The wires passed between the rolls, along with the sheet, and, had the rhomboidal bases been preserved, the wire would have been bent backwards and forwards at angles of about 30 deg.* to the per-

* The angles really are 35deg. 16min., and 19deg. 28min., as those with mathematical tastes may discover.

pendicular, and, straightening under strain, it would no longer have prevented sagging.

It is manifest from this consideration that, similarly, the rhomboids of the foundation are prone to sag; besides, it must not be forgotton that all substances, unless absolutely non-elastic, when bent are subjected to molecular strain, which operates in tending to restore straightness to them when softened. If a sheet of wax be bent by the fingers, it will be found (especially when warmed) to partially regain its original shape. In like manner, the flat wax-sheet is bent backwards and forwards into "Vandykes," in the horizontal as well as perpendicular line, as the cell bases are being marked upon it. The warmth of the bees, whilst elaborating the comb, inclines the sheet to reduce the bending it has received, and so become longer than the top bar holding it, compelling it thus to assume a waved form from end to end, while, from the same cause, its perpendicular measurement is increased—an effect all must have observed. My brush-made sheets flowed as liquid wax into the form they were intended to assume, and so possessed no such tendency. The cell-wall in foundation, then, is the solidifier, and hence needs, as Mr. Raitt has so wisely shown, to be made to fill the cut of the rolls. Theoretically, it would appear, from the foregoing, that flat-bottomed foundation would be stronger than that bearing the impress of the rhomboids. Practically, the opposite is true. I personally inspected in an apiary, last summer, over one hundred sheets of flat-bottomed foundation, that had broken down and sunk into every conceivable curve, by the side of sheets made on a Root machine, not

one of which had failed; and yet the theory is not at fault. In the former, the rhomboids are small and the cell-walls very wide, most of the material forming them being driven from under the dies: each wall, in fact, is made by two lots of wax flowing, during the squeeze, towards each other, but which never become actually one, and, as a result, present little resistance to fracture or tensile strain.

The mischief wrought by the wires amongst the larvæ led me to experiments which some may yet repeat with advantage. I placed on the face of the foundation, perpendicularly, and at each $1\frac{1}{2}$in., lengths of fine sewing-cotton, previously dipped into thin glue, passing the finger along them, to bring them into contact with the incipient cell-walls. The sheets, under trying conditions, were given to bees, when no trace of sagging occurred, for each cell-base acted as a bow, of which the cotton was the string, preventing the points of attachment from receding from each other. The cotton, after some days, is teazed away by the bees. A great variety of fibres were experimentally used, glued human hair answering much better than most. Political economists say that the value of an article increases with its scarcity; so my experiments with this material had to be discontinued on the ground of extravagance. A young lady, it is true, came to my relief with a beautiful lock, but not until fine silk had shown itself to be the best substance hitherto tried. This was at first built in near the base of the cell, but wherever it crossed from wall to wall it was soon nibbled completely away. Those, then, may venture to give foundation anywhere, and

anyhow, who will devote sufficient time to fix it by molten wax, and then glue to it the finest sewing-silk, in the manner described. While watching these experiments, a method of procedure occurred to me which I venture to think has been inadequately understood by British bee-keepers, or it would have been far more extensively adopted. If a sheet of foundation be drawn out on one side, much in advance of the other, its free points will curl towards the less complete side, because drawing out involves some expansion, as we have already seen. It was clear to me, that not only drooping needed preventing, but curling also.

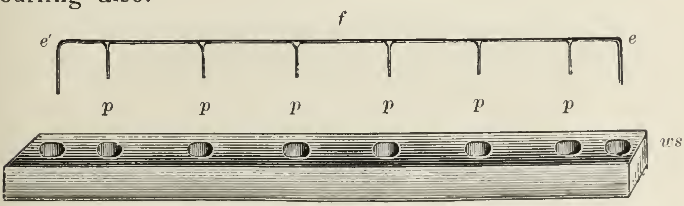


FIG. 57.—TOOL FOR MAKING FIXERS (Scale, ⅓).
ws, Wooden Strip, Perforated; *f*, Fixer; *p*, *p*, Pins.

I cut No. 18 tinned wire into lengths (*f*, Fig. 57) about 2in. greater than the depth of the frame, and then soldered to each, by their heads, six common pins (*p*, *p*, *p*). These were easily placed for the soldering by making, in a waste board, a coarse saw-cut for the wire, and six finer ones, 1¼in. apart, and across the first, in which to lay the pins, the heads of which were wetted with solution of chloride of zinc and sal ammoniac, and then touched with a copper bit and a particle of solder. Next, a wooden slip (*ws*), a bare ½in. thick, was prepared, and pierced

with holes so placed as to receive the pins and the ends of the wire (*e*, *e'*), which had been turned up over the top and bottom bars of a frame. The fixer (*f*) was now brought down to *ws*, when cutting-pliers removed the ends of the pins flush with the lower face of the slip. To fix the foundation, use the board (Fig. 52), and place the foundation precisely as for waxing, bringing it well up to the top bar. Now place the fixers as in Fig. 58, putting one near to each end, and driving the pins decidedly, and at once, through the foundation, taking care not to work the pins loose by any attempt at re-adjustment,

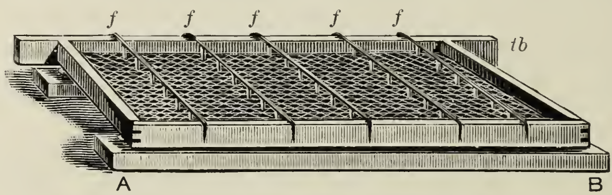


FIG. 58.—CHESHIRE FOUNDATION-FIXERS (Scale, $\frac{1}{6}$).
A, B, Board; *tb*, Top Bar of Frame; *f*, *f*, *f*, Fixers.

and the work is complete. When the frame is lifted, the foundation will be found to be so solidly held that no ordinary shaking will loosen it from the pins. The frames may be carried horizontally, in piles of a dozen, anywhere about the apiary, to be given to such stocks as may chance to need them.

It will be seen at once that sagging is impossible, the sheet being held by thirty distinct points, and, in addition, that twisting or curling is entirely prevented, since each point cannot move from the centre of the frame width. Considerable experience has shown that when swarms, in hot weather, are pro-

vided with foundation alone, held by my fixers, it is well to add waxing, as without it here and there the sheet may droop over from the top bar. With this precaution, perfect combs are, under all circumstances, produced, and even pieces of foundation, fitted together, will yield results but little less perfect than whole sheets.

The first effort of the bees is to fix the foundation to the pins by building around them little struts of wax, but if a tiny hole be made near the pin, the bees on the opposite side of the sheet seem to communicate through it and dig away the wax, until a hole nearly ½in. in diameter is made; it would appear, with the idea of removing what they consider an obstruction. All this shows the importance of fixing at once the foundation in its proper place. If the sheet be cut so large as to reach the bottom bar, the bees are disinclined (they are not properly able) to finish out the lowest cells, while they often nibble for themselves passages (pop-holes). All things considered, although the fixers permit of filling the frame, it is unwise to take advantage of it. The wire should not be thicker than the size already named, or time will be wasted by the bees in building struts of comb from its side towards the foundation. The new comb produced will be able to sustain all the contingencies of a journey from the first without breaking, by simply leaving the fixers in position, although, of course, they render a few cells useless. When the comb is rather more than half built out, my general practice is to remove the fixers by a rocking movement, accompanied by a pull. The cell walls sur-

rounding the pins are somewhat broken, but an hour at most finds all repairs completed.

With the object of giving combs solidity, thin pine boards have been coated with wax, and then passed through a flat-bottomed foundation machine. The idea originated in America, and was not accounted successful. Good combs are at times built; but if the bees, in excavating, get down to the resisting wood, instinct seems to tell them that no cell can back on to the one in hand, and they immediately start from the wood-face a strut, which begins a comb, built *between* the boards instead of upon them. This instinct prevented more than a very partial success in my attempts to get cells built upon glass, in order to study the development of the egg and larva; but it is by no means difficult to secure what many would regard as a curiosity—a comb, three cells thick, actually having two midribs. Next a sheet of brood, place a slab of *sealed* honey in a full stock, giving rather an excessive interspace. Draw it back, little by little, as cells are built up on the face of the honey; eggs will be laid, and brood in due time matured. I have had several such combs in my possession.

It is usual, at the present time, in America, to prevent sagging, and secure flatness and solidity, by "wiring" the frames, and subsequently fixing the foundation in place—a practice but little followed, as yet, in England, partially, no doubt, because of our more temperate climate, while we use sheets of considerable thickness. The top and bottom bars are finely pierced, as in Fig. 59, when fine tinned

wire (No. 30) is cut into lengths sufficient for one frame; it is then drawn through the central hole (*a*), leaving equal lengths free, so as to finish without waste, when it is sewn backwards and forwards, as indicated in the figure, and finally fastened, a thin nail (*n*) being commonly used. Frequently, a central perpendicular strip of doubled tin is added, as a stiffener, to prevent the bending of the bottom bar under strain, and two diagonal wires are used. These break up the continuity of the comb, but give great stability. The foundation is now placed on the board

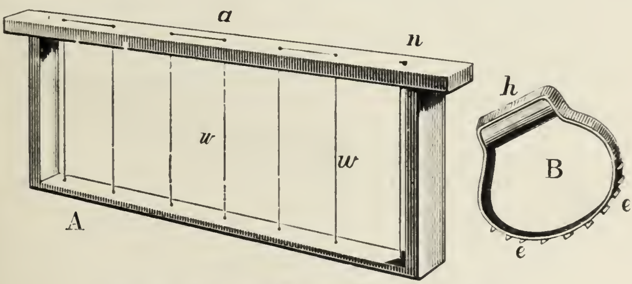


FIG. 59.—WIRED FRAME AND EMBEDDER (Scale, $\frac{1}{8}$).

A, Frame—*w*, *w*, Wires; *n*, Nail. B, Embedder—*h*, Handle; *e*, *e*, Embedding Edges.

(Fig. 52), and the wired frame put over it, care being taken that the wax sheet is well up to the top bar. The wires are now to be sunk into the wax, and this operation needs a fairly high temperature, 80deg. being none too hot. A small, flat-ended nail, or a bradawl, will answer by simply pressing the wire down at intervals of from $\frac{1}{2}$in. to 1in., but it is best to use an embedder (B). Grasping it by the handle (*h*), the little tin projections (*e*) soldered to its curved face are brought, in sequence,

into contact with different points of the same wire, which is thus driven down to the centre of the foundation. Some use the wheeled apparatus (Fig. 60). The method of operating is obvious. The wheel, which is stellate, is grooved at the edge, so as to hold the wire beneath and between the cutting points (*p*, *p*). As the wheel is driven, the wire, in short lengths, is pushed down into the body of the wax.

The foundation is now very securely held, but it cannot be safely given in all cases without attachment to the top bar. Waxing in the usual way

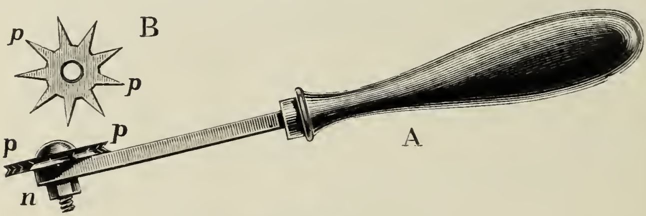


FIG. 60.—WHEEL EMBEDDER (Scale, ½).
A, Complete Tool—*p*, *p*, Points of Wheel; *n*, Nut. B, Side View of Embedding Wheel.

would be my preference, but some slightly turn up the edge of the foundation and bed it into the very material of the top bar by squeezing with a chisel, or its equivalent: this process—which occupies more time, requires more wax, and is less neat, than work done by the smelter—must clearly be performed before the embedding.

Mr. Given's press does not emboss its foundation between rolls, but between flat dies, and frequently the frames are first provided with wire, upon which the plain wax sheet is laid, when the dies, which fit

inside the frame, and are hinged together, are applied above and below, and the whole passed through the press, turning out perhaps the most solid midrib produceable, as the wax by this process suffers no extension in area. The method is, however, only suitable to a very large apiary possessing its own press, as frames already "wired and waxed" would occupy much room, and need careful packing for transmission. The "Given" system—metal taking the place of plaster—is so exactly like a method of my own, that the explanation of the latter will make the former more intelligible, while it will redeem a promise given

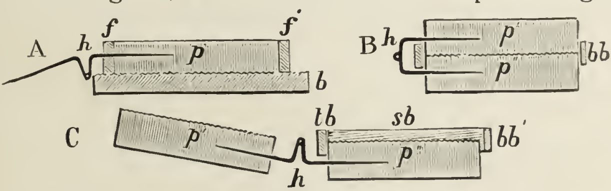


FIG. 61.—CASTS FOR IMPRESSING SHEETS, SECTION (Scale, $\frac{1}{10}$).
A—*b*, Board; *p*, Plaster; *ff'*, Frame in which Plaster is Cast. B, The Mould Sheet—*bb*, Bottom Bar of Hive Frame. C, The Mould Open—*tb*, Top Bar; *sb*, Side Bar of Frame; other Letterings as before.

on page 181. Take a sheet of good foundation, place it upon a flat board (*b*, A, Fig. 61), and make a frame of wood (*ff'*), 1¼in. deep, and slightly smaller than the hive frame used in the apiary. Cut slots in one side, to admit two bent garnet hinges (*h*); grease, to prevent adhesion; and place, with the hinges (*h*) in position, over the foundation, which has its cell bottoms filled with water, from which all air bubbles are to be carefully removed. Now mix sufficient plaster of Paris (dentists' by preference) to fill the mould, and pour in. Its weight will displace the water, which will flow off at the top. The plaster

having set, invert the whole, so that the foundation is uppermost. Now repeat the process; break off the two wooden frames used, open your mould, and remove the foundation, and you have the form B. Dress the edges as may be necessary, and the apparatus is complete. Sponge the faces of the mould before using. If you desire wired foundation *à la* Given, wire the frame, and place it as in C. Soften your sheets in hot water as much as possible without endangering them; place one on p'', and close the mould instantly. Although the impression will be much inferior in sharpness to the original, it will be worked out by the bees into comb not to be excelled.

Our outline of plans would be incomplete were we to omit that foundation has been made by casting, using an apparatus much like that of Fig. 61, but (it is only fair to myself to add) of considerably later date. The mould is partly opened, is submerged 2in. or 3in. in liquid wax, hinged side down. By a sharp movement the two faces are brought together, and the wax thrown up between them. Surprisingly perfect sheets are in this way produced.

We now leave the mechanics of the question for a few considerations, which have too often remained unnoticed; and first in order, the one touching size of cell claims our attention. Very careful measurements of some hundreds of combs, built by numerous colonies of black bees, showed only inconsiderable variations and an average of 14½ cells, measured across their parallel sides, to each 3in. Yet these bees experienced difficulty, as already stated, in build-

ing out impressed sheet, made by the Mehring plates (Fig. 47), giving barely $15\frac{1}{4}$ cells to the same space, indicating, as another fact will presently yet more forcibly show, how sensitive they are to the size of the cell. It is apparent also that the different races of bees we have amongst us do not all make the cradles for their larvæ of the same size; *e.g.*, the blacks build drone-comb four cells to the inch; but I have a fine large slab of most perfect workmanship, turned out by a Carniolan stock, measuring all over it accurately $3\frac{1}{2}$ cells to the inch. There now lies before me a comb, started with 2in. of foundation, $14\frac{1}{2}$ cells to the 3in.; but the eye, running along the two opposite diagonals, which are at 60deg. to the horizon when the comb is *in situ*, shows that the lines of cells are curved from each other, proving that the bees have disagreed with the sized cell of the foundation, and have actually contrived near the bottom of the slab to make their cells 14 to 3in. only. Both Mr. Raitt and myself pointed out many years since that Root's earlier foundation, giving $13\frac{1}{2}$ cells to the 3in., was accepted only with ill grace, and that the combs were often modelled into a mixture of drone, worker, and misshapen cells; and Mr. Raitt suggests using this very foundation for sections, because it would not suit the taste of the queen any way. Yet, is it not possible that there are certain strains of the larger races—the Carniolans, by example—to which it would be even more acceptable than that which we regard as orthodox? The sizes of the races are so characteristically marked, that this point must have practical importance. In

P 2

two stocks representing average Carniolans and Cyprians, weighing evidenced the disparity to be considerable, that between the workers being greater than that between the drones. Taking twenty of each for purposes of comparison, I found—

20 Carniolan drones	weigh	66grs.
20 Cyprian ,,	,,	60 ,,
20 Carniolan workers	,,	40 ,,
20 Cyprian ,,	,,	28 ,,

It is clear at once that variations in size of foundation are, at any rate, desirable, and the actual differences between those combs which have been taken as models may perhaps explain, to some extent, why the rolls of different makes have been set to different gauges, although reasons are not wanting for supposing that mere accident has had more to do with it.

Mehring plates	give	30½	cells	to 6in.
Long's foundation	,,	30	,,	,,
Raitt's ,, ...	,,	29	,,	,,
*Flat-bottomed foundation ..	,,	28	,,	,,
Original Root ,, ..	,,	27	,,	,,
Flat-bottomed drone foundation	,,	25	,,	,,

Natural worker-comb seems to vary between the extremes of 30 and 27 cells to the 6in., and drone-comb between 26 and 21 to the same space.

The thickness of foundation has been determined a good deal by the demand made upon it for resisting strain, and hence that running about five superficial feet to the pound, *i.e.*, of $\frac{1}{25}$in. in average thickness, is usually recommended for brood-chambers. Were

* The size of this foundation cannot be stated absolutely, since it fails in not measuring the same along the three diagonals, which cut the parallel sides of the hexagons at right angles.

these sheets pared down to the wondrous thinness of natural comb (Vol. I., page 172), they would furnish a sufficient amount of wax to complete the structure, which contains no less than eleven times its own area of tracery (exclusive of the capping). It is interesting to note how this immense amount of surface as cell walls and midrib is arranged. A, Fig. 62, represents, twice natural size, the edges of the former, which are supposed to be divided from each other as indicated. If we turn the separated sides *a*, *a* to the centre of the cell *a′*, they will there exactly meet,

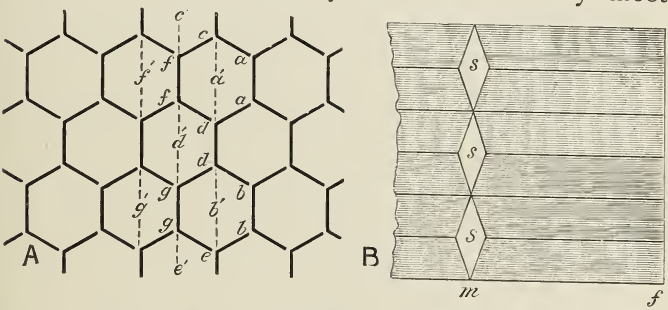


FIG. 62.—DETAILS OF CELL WALLS (Twice Natural Size).
A, End View of Cell Walls. B, Side View of ditto—*f*, Face of Comb; *m*, Middle Plane of Midrib; *s*, *s*, *s*, Spaces Closed by Midrib.

covering the dotted line; and if this process be repeated with each cell, as suggested by the lettering of the illustration, we shall convert the hexagons into a series of perpendiculars, placed at half the cell-diameter from each other. (If there be any difficulty in following the Figure, a few hexagons, built up on a table with lucifers, may be transformed into perpendiculars at once.) Having this method of converting the polygons into an equivalent of such simplicity, the length of line of which is immediately

ascertainable, it is evident that we have only to discover the exact depth of the cell walls, to be able to calculate the amount of surface these contain on any given area of comb; but the structure of comb does not quite so easily submit to estimation as some would imagine, the apparently simple question of cell depth having too many mathematical subtleties about it to make it fitting to fully discuss it here. It will be seen by B (Fig. 62), representing the side view of the opened-out cell walls, that those of each cell meet the median plane of the midrib (*m*) in three points (for the top and bottom lines of the Figure join when folded round in the natural position), and that between these the cell sides fall short of the middle line. The cell walls do not, therefore, make up the full width of the comb, part of which (represented by the spaces *s*, *s*, *s*) is filled out by the inclined rhombs forming the bases. Calculation shows the deficiency to be about $\frac{1}{22}$.* If, *e.g.*, the cells are $\frac{1}{5}$in. in diameter, or—which is the same thing—the perpendicular lines into which their sides are convertible $\frac{1}{10}$in. apart, and the comb 1in. thick, it is clear that every square inch of comb will contain $\frac{21}{22}$ of ten square inches of cell wall. To this the midrib must be added, the area of which, as consisting of rhombs inclined to the cell face, must be greater than the area of the comb itself, the excess being

* The general formula for all comb, drone or worker, I find to be—

$$\frac{\text{tan. 19deg. 28min.} \times \text{cell diameter}}{\sqrt{3}\ \text{(comb thickness)}}.$$

The whole calculation is too lengthy to be introduced; but a study of a well-made piece of comb or foundation, some knowledge of trigonometry, and a little patience, will enable the reader so disposed to verify it.

about $\frac{9}{40}$ of the whole.* And thus the cell walls and midrib together make up eleven times the comb area very closely. If to this be added the sealing, we find that the industrious labourers have to produce a surface of wax tissue of upwards of 1300 square inches to furnish a Standard frame, or about enough, in a hive of eleven frames, to ceil a room ten feet square.

Thick foundation would, we have said, furnish sufficient material for the completion of the comb; but the bees very rarely work more than half their cell walls out of even the stoutest sheets given them, leaving a thick mass of yellow wax in the neighbourhood of the angles of the rhombs. It has often been noticed that the amount of paring to which the foundation is subjected varies according to external conditions, and that, especially when busy honey-gathering, the bees scrape the foundation but little. The reason is not far to seek. The cell of worker-comb is not much larger than is absolutely necessary to admit the wax-builder's body. The scraping and thinning of the cell base supply materials which must be stowed somewhere until it can be put into form, and the instinct of the modeller leads her to pack it along the rim of the gradually-growing cell walls; but heavy additions cannot here be made, or the little worker would herself be prevented from getting at the seat of her operations. When the cell wall is half drawn out, the foundation is, of course, only partially

* The total area of the rhombs is to the area of the comb as $\sqrt{3} : \sqrt{2}$.

reduced in thickness, and, did the cell remain empty, the drawing-out would be continued, reducing the accumulation on the rim, when wax would be economised by further scraping, so as to secure material for the extension or completion of the structure; but the return of the foragers, in prosperous times, puts nectar on to the bases of the half-drawn-out cells, or the queen bans disturbance by the deposition of an egg, and further thinning is henceforth entirely prevented.

Drone-cells, on account of their greater diameter, permit of almost unlimited heaping-up of material on their

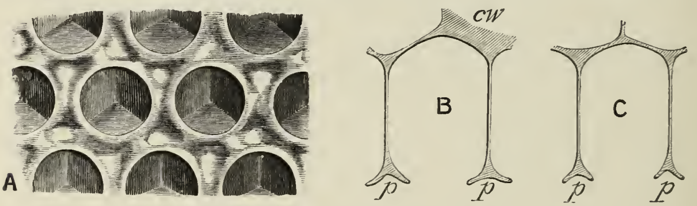
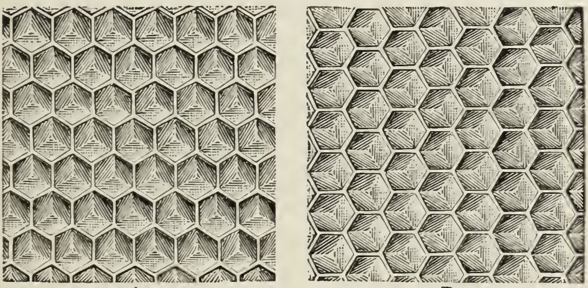


FIG 63.—HALF-FINISHED CELLS ON DRONE-FOUNDATION (Twice Natural Size).
A, Cells showing Pittings in Heaped-up Wax. B, Cell in Perpendicular Cross Section—*p*, *p*, Pittings; *cw*, Cell Wall. C, Cell in Horizontal Cross Section.

edges, and so drone-foundation is far more commonly completely thinned down than that of worker size; A, Fig. 63, *e.g.*, giving an exact representation of comb worked on thick drone-foundation, showing the immense width to which the cell walls may be extended, while yet yielding to the worker ready entrance. The strange disposition to hollow the surfaces, probably derived by the bees from burrowing ancestors, is very noticeable; and to such an extent has this been carried in some specimens in my possession, that the pittings have actually been converted into inci-

pient cells. We thus learn why foundation the cells of which are rather smaller than the size most acceptable to the bees to which it is given, is but little thinned down, while the foregoing considerations show that foundation five square feet to the pound gives no greater aid to the bee than that little more than half its thickness. The excess of wax the former contains may be, and is generally, of service in adding solidity during drawing-out, but it remains in the midrib, where it is rather a disadvantage. Strict economy is inconsistent with the use of this heavy foundation, while that of lighter make (seven feet or



A B

FIG. 64.—FOUNDATION CORRECTLY AND INCORRECTLY SUSPENDED.

thereabouts to the pound), aided by my fixers or any of the several plans indicated, will yield combs which leave nothing to be desired.

In natural objects, even small differences are usually not without a meaning, and here foundation, which is an imitation of a natural midrib, should not be suspended sideways in the frames. A piece of comb, as built, will always have its hexagons disposed as in A, Fig. 64, the perpendicular walls on both its faces giving, in consequence of their position, the

highest possible resistance to downward strain. As comb or foundation so placed has no horizontal walls, it is clear that it will have no perpendicular ones if suspended as at B. The sides of the hexagons are in this case either horizontal, and consequently useless in resisting down strain, or are subjected to the great disadvantage of all inclining 30deg. to the perpendicular, towards which any pull would tend to bring them, thus throwing the whole of the tension on the comparatively weak midrib, making stretching, distortion, or even rupture, all but inevitable.

When we inquire how it happens that bees *naturally* arrange their cells in a manner which statical laws show to be the most desirable, we are met by facts as beautiful in their adaptation as they are remarkable in their method of achievement. Some of these attracted the attention of, and greatly charmed, the older Huber, although it appears to me he failed to see their inner meaning, or give to them their proper interpretation. We have already learned (page 170, Vol. I.) that each surface involved in comb is, in all respects, the result of interaction of two bees scooping simultaneously, or of one bee working alternately on its opposite sides. If we now take a piece of foundation, cut at its top edge, through the upper angles of the hexagons, as at A, Fig. 65, and bring it against the top bar (*tb*), we find we have given to the bees, according to our last statement, an impossible task, since the openings *o*, *o* are too small to permit a bee to enter in order to operate on the upper surfaces of the sides (*s*, *s*) of the hexagons. But this

failure on the part of the bees is of the highest service, for could the hexagons of the topmost row be constructed complete, the attachment of the resulting comb would be of the most fragile description, since the sides (*s*, *s*) would, from their position, be little able to resist strain. In effect, these sides are absolutely ignored, and cells of a special form, really irregular pentagons, produced (B), which have four sides of wax, closed above by the top bar forming a fifth. These cells, called by Huber, under a misapprehension, cells of the first row ("*le premier*

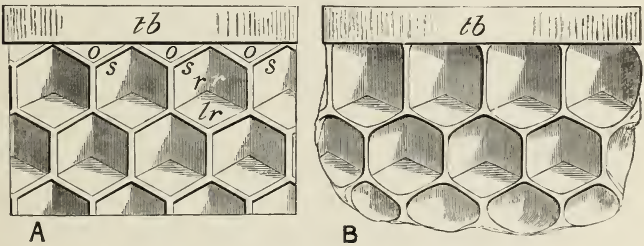


FIG. 65.—ATTACHMENT CELLS (Twice Natural Size).
A, Comb Foundation—*tb*, Top Bar. B, Foundation, partly drawn out.

rang"), but which I purpose, for a reason stated hereafter, denominating "attachment cells," give, by their extended perpendicular sides, the strongest possible fixing, since the strain is absolutely in the direction of their length, while the inability of the bee to reach into a rectangular corner necessitates a thickening of the upper extremity of the wall, where it joins the top bar, thus adding to the solidity of the structure.

The modification of the attachment cell is not, however, confined to the cell wall, the rhombs being

so altered that they, too, secure the highest possible rigidity, and in the following manner. The two lateral rhombs (*r*, *r*) are carried upwards to the top bar, ceasing to be rhombs, and becoming trapezoids. These have a much less inclination from the perpendicular than the lower rhomb, *lr* (see footnote, page 200), and even this inclination is reduced by the relative positions of the bees modelling them on opposite faces of the comb; while, from a reason before given, they are thickened at their upper edges.

The full beauty of these adaptations cannot be seen without studying both faces of the comb and noting how they are related to each other; and, probably, many are unaware that, while all cells (save the attachment cells) on one face of the comb may be alike, they must, of necessity, differ from all those of the opposite face. In dealing with this matter, although neither face can rightly be regarded as front or back, it will be a convenience to follow Huber, and call them anterior and posterior respectively. If A (Fig. 66) represent the posterior face of a piece of comb naturally built to a top bar (*tb*), B will be the form of the anterior face of the same piece, which comparison shows to differ from A in almost every particular. The attachment cells, it is true, have, in both, the same beautiful adaptation of their sides, previously noticed, but the bases of those of the posterior face contain but two trapezoids each instead of two and a rhomb, and these are not paired, as are those of the anterior face. Trapezoids 1 and 2, *e.g.*, belong to one cell in A, and to two

distinct cells in B. The lower rhombs in the line *a′ b′* belong to the attachment cells in B, while their opposite sides (*a b*) form the upper rhombs of the second row of cells of A; these cells, and those of every other row, having their rhombs arranged as those of B inverted—*i.e.*, the anterior face of a piece of foundation becomes the posterior one by simple inversion: so that foundation, although having sides, as we have already seen, has, strictly speaking, neither top nor bottom; or, with regard to it, these terms are convertible. The variation in the height of corresponding

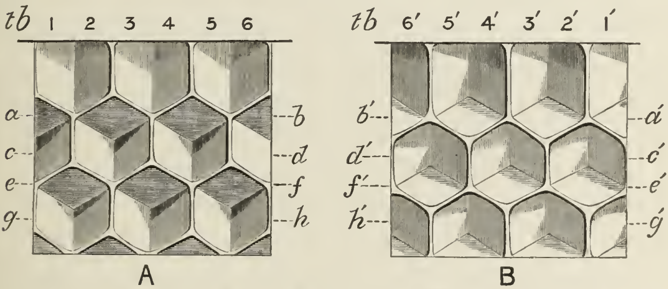


FIG. 66.—OPPOSITE FACES OF SAME PIECE OF COMB (Twice Natural Size).
A, Posterior Face. B, Anterior Face. Similar letters and figures refer to opposite sides of the same parts in each.

rows of cells on the two faces, is indicated by the similarly lettered lines in the Figure, and, while it is clear that the attachment cells of the posterior face (A) must be sufficiently deep to admit a bee, those on the anterior face must be deeper by half the diameter of the ordinary cells, measured between the angular points instead of the parallel sides; *i.e.*, they must be far too deep and irregular in form, both in the sides and bases, to be suitable to breeding purposes—a point the import of which we shall presently see.

Huber was so pleased in discovering that the cells of "*le premier rang*" obeyed all the laws of construction, that he erroneously concluded that they were so formed in order that the laws of construction might be obeyed. Had he followed up his investigation, which seems since his day to have had a long slumber, he would have found that obstacles placed in the way of the bees lead to the formation of these special cells in any row, and in any position with regard to the horizon we please. It is only necessary to lift an ordinary frame of comb out of a hive, to see that the cells built against the frame side are constantly like to those Huber supposed to be found in the first row only; and when by chance (and this happens frequently) the comb is built down in part to the bottom bar, we have cells again of the form under discussion, except that they are upside down. From this the inappropriateness of Huber's title justifies the new name I suggest—"attachment cells."

The unsuitableness of the irregular cells for brood-raising has been noticed in passing; yet this unsuitableness does not bar their fitness for storing honey, and so bees build out such to the side bars of their frames to stiffen their comb, and receive their store until they come down to the line of the brood; but here (see Figs. 7, 14, and 27), since such additions would increase labour but not accommodation, cells of true form only are constructed, and these naturally stop short of the hive or frame side, as the case may be. The fact that bees thus attach their combs laterally as far down as the honey, has been cited times without number, and, as I take it, most

illogically, in favour of close-ended frames; for it has been said bees so build in order to prevent a flow of air round their comb, and sustain temperature, the supporters of the argument ignoring utterly the obvious truth that warmth is really *vital* to the brood, but comparatively unimportant for the honey. Had this been their object, surely the attachment would have been continued all the way down the comb side. An unprejudiced examination of the question can, I venture to assert, lead to no other conclusion than the one I have advanced. The difficulty bees have in filling up an accidental hole in their comb points in the same direction. So soon as the hole is too small to readily admit them, their work becomes confused, irregular, and patchy; while, if section racks in which breeding has unfortunately occurred be examined, they will frequently give a corroboration of my position. The foundation, it may be, is attached laterally, and very similarly, in two boxes: in one honey is stored, and here the cell walls are all built out, the nectar having been added, *pari passu*, with their growth, and sealing to the very wood covers all; but in the neighbouring box, where the queen has volunteered her assistance, the midrib, as before, continuous to the wood, remains as at first, while the cells are completed only so far as the bees could work on both sides of the whole boundary of each hexagon. Indeed, very irregular surfaces for attachment of comb so impede the bees, that they are often content with thick additions of wax to give solidity. In this way, combs in skeps are frequently quite thin against the straw, as noticed under "Bumping."

Our chapter on Bee Architecture (Vol. I.), together with this we are now concluding, should leave our minds impressed with the richness of that treasure-house of beauty we call Nature. Man's foundation has, indeed, accomplished much; yet not because it is "an original," but because it is "a copy." It aids the bee by spreading out a wide field upon which may be exercised from the first the modelling energies of multitudes, which, in a state of nature, must, in quiescence, hang and wait until the labours of those above shall carry down the growing tracery to within their reach. It aids her, too, in saving the exhausting and expensive secretion of wax, by giving her second-hand material to use as new. Not less it aids her master, by compelling her to bend her will to his, and build upon the plan that he has traced, forming also her cells of the size that he directs, and so banishing from her home the drone he does not desire. But he has to "stoop to conquer." First, he must learn of her the wonders of her ways—painfully and slowly tracing out the intricate relations of the form which secures the fullest economy, the greatest strength, and the largest cell-accommodation; and then, humbly imitating the pattern she has set, showing a wisdom she has not learned, and too profound to be her own, he verifies the proverb that "in all labour there is profit," by tripling a prosperity in which he is the self-constituted partner.

CHAPTER VI.

CONTROLLED INCREASE.

Disadvantage of Natural Swarming—Variation and Selection—Importance of Artificial Selection to Improve the Race—Artificial Swarming of Skeps—Driving: Open and Close—The Rationale of Driving: Cautions respecting—Transferring—Transferring-boards—"Three out of Two"—Plans with Frame Hives—How to Examine Combs of Latter—Handling the Queen—Making Swarms by Jerking and Brushing—False Cluster—Swarm-box—Weighing Bees for Sale—Number of Bees to the Pound—Nucleus-swarming—The Prevention of Swarming.

THE hive bee's natural means of increase, "swarming," demands so much time, and is accompanied by such uncertainty and inconvenience, that but few apiculturists nowadays have not taken the matter, as far as practicable, into their own hands, increasing the number of their colonies, when they deem such increase desirable, by a variety of methods called generally, but with doubtful accuracy, "artificial swarming."

It is needless to point out that if the question of colonisation be left to the determination of the bees,

swarms will now and again settle in most inconvenient positions, or come off at most inconvenient times, or be lost by leaving when no watcher is at hand; while, on the other side, the seemingly perverse insects often most tantilisingly idle, week after week, in big clusters at their hive door and swarm not. Unfavourable weather, also, will sometimes, after all things are ready, keep the queen back until the princess intended to succeed her is necessarily destroyed.

But these evils, although the most conspicuous, are by no means the most important ones inseparably connected with natural modes of increase. An indication of two or three of those not at first apparent, will make clear my meaning. It has already been pointed out (page 125) that the swarm departs, normally, so soon as the queen-cells are sealed, although frequently the bees leave several days earlier. Eight days subsequently, or thereabouts, the first princess hatches, and in seven days more, all things being favourable, mates, two days later depositing her first eggs; so that the parent stock is seventeen days at least without a fertile queen. This, occurring in the height of the laying season, is a far more serious check than the loss of the whole of the bees of the departed swarm, which probably did not contain more than 16,000, or at the most 20,000, individuals (the number of bees in swarms is usually much overstated); for a present queen could, during that seventeen days, have deposited—according to her quality, the number of bees attending her, and the condition of her hive—between 30,000 and

40,000 eggs, which could have been nurtured into adult bees at an expense of bee life far less than the difference between the number in the swarm and the number of eggs laid.

From all this it is clear that any decrease man can, by management, make in the seventeen days aforesaid, will be to the great advantage of his stocks; and we shall presently see that it can be easily reduced one-half, while very workable plans practically annihilate the interregnum altogether. Again, in natural swarming many queen-cells are built (page 125), the contained larvæ of which are all lavishly nurtured at great cost in time and energy, yet usually one only of the resulting queens reaches the stage in which she pays for her bringing-up: the rest are ruthlessly slaughtered and cast forth—a loss pure and simple to the community which at first laboured for, and then destroyed, them. In a well-managed apiary, however, in which artificial swarming is followed, this leak of wealth is well-nigh stopped, and the queens which are supernumerary, and so, under natural conditions, necessarily devoted to destruction, are, in the greater number of instances, transferred to other colonies, which are thus saved the cost borne by their neighbours. But. I would lay the deepest stress upon a point yet to be considered. Attentive observation will show that, amidst a well-marked uniformity in anatomical structure, instincts, and capability, there is a range of variation in the bee which is by no means narrow. In half-a-dozen stocks of the same race, which start the season in similar hives, with equal quantities of comb, with like population, the same forage-ground, and identical

treatment, the results will often be extremely dissimilar; and while I know, from careful investigation, that these disparities are occasionally the result of unhealthy conditions, from which some stocks have suffered and others not (for bees are subject to diseases in a variety, and with a frequency, of which the bee world has been ignorant, as I intend more fully explaining hereafter), yet generally the divergencies follow from variations in the bees themselves, which variations, if philosophically handled, open up possibilities to the apiculture of the future, of which, at present, we have little idea. In a certain sense, the queen, or, more truly, the queen and the drone with which she has consorted, are the stock. In a measure, this has been some years recognised, and many a queen has suffered decapitation because of the naughty ways of her children; but if in temper she multiplies herself in her progeny, it is equally true that she is the medium by which every other quality and capacity is made to inhere in the colony which she heads.

Returning to our hypothetical stocks, we find one, it may be both in population and in wealth, forging rapidly ahead of the rest. We tier section rack upon section rack, and still the bees hold on filling the space given to them; and when the honey-season closes, we discover we have a magnificent result, beating our record, and giving us, perhaps, a reputation for bee-mastership which we little deserve. The next stock, possibly, after refusing our sections, swarmed and swarmed again, and so has made us the proud possessors of a little string of new colonies, with

which our apiary in the coming year shall have, as we fondly hope, larger possibilities than it has had in the past. The rest have been, perhaps, an all-round average—some better, some worse—but nothing especially remarkable. Our half-dozen stocks thus left to themselves, so far as increase is concerned, present us with an instructive type of a process which has been at work through the ages, amongst the honey bees, in a state of nature. Variations have constantly been occurring; but those bees which have been the largest hoarders of honey have been, on account of this characteristic—especially if it has been very marked—restricted in any effort to multiply the race by swarming. The queens of these, the most valuable stocks, have left no progeny, and the variation which (from the bee-keeper's point of view, at least) is most worthy of perpetuation, and, if possible, of augmentation, has died with the queens which have given it origin. But not so with the persistent swarmers, which, in the nature of the case, amass less wealth: theirs it is to raise new queens, start new colonies, and so strongly impress their own variations upon the bee-life of the future. It is true that *reckless* swarmers, rushing out to start new colonies at unfavourable seasons, do not naturally perpetuate their peculiarities, for they succumb in the struggle for existence; but, after this abatement is fully made, the fact remains that natural selection unduly favours the swarming impulse, while it gives no encouragement to those variations which lead to a collection of honey considerably in excess of the needs of the colony gathering it.

Similarly with our own bees: the golden opportunity of improving the race has been allowed to slip through our fingers. Our apiary is increased truly, but with bees of the *swarming* type, not conspicuous as honey-gatherers. What should we think of the stock-raiser who would save for breeding purposes the cow-calves from the mothers that most quickly go dry, and send those of the heaviest milkers to the butcher? If we see the case clearly, should we not deem ourselves guilty of equal folly in permitting the multiplication of the less desirable while making no effort to prevent the extinction of those exhibiting much-coveted peculiarities? Is it our belief in the natural, and the condemnation of that we call artificial (page 115), which send us astray? If so, we need to be reminded that well-chosen artificial processes are not *against* natural ones, but in extension of them. Is it not truly natural for man, to whom has been given "dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth," to exercise his mastership according to the guiding of that intelligence without which his dominion would be a mockery—*i.e.*, to interfere by introducing the so-called artificial, in order that that which is already good may be better, and he, the master, secure, in the fullest attainable measure, the supply of his needs or the object of his desires?

Natural swarming, then, which gives natural selection full play, or even possibly, through unwise meddling on the part of the bee-keeper, causes it to work still more inimically to his highest interest, can never secure results so favourable to apiculture as those

that must flow from wisely-conducted artificial methods. Artificial swarming has well-nigh outlived opposition: it is now admitted to save time and trouble—and, unhappily, as it is conducted in very nearly every apiary, it does no more, for the philosophy I am now advocating seems to have been all but absolutely overlooked; but we ought to claim, as we are undoubtedly able to achieve, immensely more than this. Man, in the wild horse and the mouflon, has had put into his hands the instruments by which animals, incomparably in advance of their prototypes, have been produced. Relatively, he has even greater power over the future of the bee, that power lying in proper attention to variation and selection. Nor must it be forgotten that variations, which are at first fitful, appearing and disappearing, are made constant and permanent by persistent following. A single decade, rightly used, with the bee, would do great things, as two or three selections per year are quite within the range of possibility; but we must leave the further discussion of this important matter until we reach the question of queen-raising.

The methods of swarming artificially are practically endless, but it will be only necessary to give such as exemplify the principles that must ever be borne in mind while making any modifications that the special object in view, or the condition of the stocks, may seem to demand. Of course, our plans will largely depend upon the character of hive with which we have to deal; and so I purpose treating the question under three heads—firstly, explaining how to swarm hives with fixed combs; secondly, those with frames not

interchangeable; thirdly, those with interchangeable frames—subsequently giving such information as will enable the bee-keeper to judge of suitability of season, ripeness of hive for increase, &c.

In dealing with skeps or box hives, the bees which would, in natural swarming, voluntarily leave have to be ejected from their house and home by a process called "driving," which has been, on account of the astonishment it is likely to awaken, constantly chosen for exhibition purposes in the bee-tent. If we are to operate upon a skep, two or three puffs from the smoker are driven into its mouth, so as to frighten its inhabitants, causing them to leave their floor-board, and retreat amongst their combs to fill themselves, with honey—they being allowed two or three minutes for the operation, during which, if the bees are known to be irritable, an occasional rap may be made upon the straw. There are two kinds of driving, both of which deserve explanation. Having provided a stool or table, so as to make our work as convenient as may be, we lift the skep, turn it bottom upwards, and place its crown in a tub (Fig. 67) or a shallow pail, and immediately place over all a second skep having the same diameter as the first. A long bandage, or jack-towel, is fastened round the edges of the two hives, in such a way that not a bee can escape. The lower hive—that is—the one containing bees and combs, is now beaten with sticks, or with the hands, to jar the whole fabric, and terrify the poor little honey-gatherers, whose composure has already been upset by the noisome cloud which was at the first shed amongst them. The beating must be fairly continuous,

but not violent, or we are likely to break the combs from their attachments (particularly if we direct our blows towards the comb face), and so bury the bees in the ruins of their city. In from one to five minutes, the wildest confusion prevails within, each bee rushing madly about; when the whole, making a roaring noise by the vibration of their wings, commence a stampede into the empty hive standing over them, from the

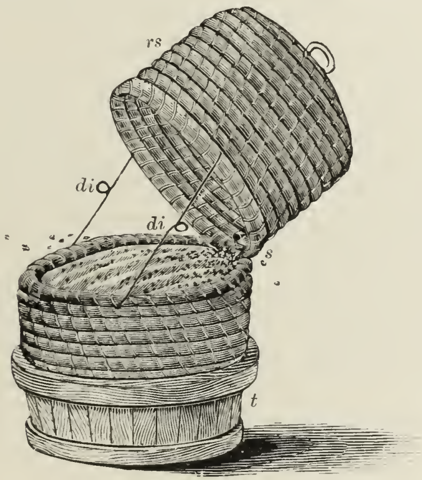


FIG. 67.—ARRANGEMENT FOR OPEN DRIVING
rs, Receiving Skep; *s*, Skewer; *di*, *di*, Driving-irons; *t*, Tub.

roof of which, a few minutes later, they may be found, by the removal of the bandage, hanging much after the fashion of a natural swarm. The method so far outlined is called "close driving," because the edges of the two hives are brought into contact, and the escape of even a single bee is prevented. In this particular it will recommend itself to the beginner, whose nervous dread of a sting yet weighs with him

in his choice of plans; but with the single exception that it may be performed by lamplight much more easily than those who have never tried it could imagine, it has little to recommend it, as, for expeditious swarming, removal of queens, &c., it is not to be compared with "open driving," which differs from the foregoing in placing the hive to receive the driven, or forced, swarm over the other, at an angle, as in Fig. 67. One, or better two, stout kitchen skewers, thrust, a hand-breadth apart, through the edge of the receiving skep (*rs*), into the rim of the lower one, serve to keep the two in the right relative position, which should present the least possible impediment to the bees in their upward march. The union should occur at the part of the circumference opposite the ends of the combs, as the several seams of bees between them are thus more readily enabled to pass into the receiving skep, and here it is that they seethe out in the greatest numbers. The shadows in the Figure show how the light should fall. Let the operator stand with his back to it, and with the skewers opposite to him, so as to command a perfect view of all that passes within. He may grasp, with one hand, the front edge of the receiving skep, which thus becomes the lid of a box, kept partially open, while the skewers form the hinge; but Mr. Hunter introduced a small wire appliance to fix the hives together, and added the driving-irons (*di*), as in the Figure, for holding the upper skep at any desired angle. Pointed sticks, pressed firmly into the straw of both hives, answer every purpose, having, like the driving-irons, the very considerable ad-

vantage of entirely freeing the hands of the operator. Commence now to drum or beat upon the side of the skep, either with the bare hand or with a stick, as in open driving, when the bees will almost immediately begin to ascend; and, as we continue thudding, careful watch should be kept for the queen, who will generally be espied eagerly seeking security by clambering aloft amongst her retreating children, who make no attempt to escape by the opening between the hives; nor do they at all threaten to use their stings. They are so terror-stricken that thoughts for their own safety entirely banish notions of vengeance, and, under these circumstances, they are harmless as flies. Generally speaking, the veil is a needless impediment whilst driving. The beginner should start with one, but may throw it off so soon as the bees indicate their subdued condition, by commencing to run upwards. At the time we lifted the stock, probably large numbers of bees were out foraging, and these, at their return, would, after a futile search for their old home, strive to enter other hives, to possibly meet the rapid despatch. An empty skep (a decoy skep), resembling the one removed, should be placed for their amusement, when they will enter, leave, and re-enter, until our operation is complete, and we are able to deal with them.

Driving for the purpose of obtaining a forced swarm is usually only undertaken in genial weather; but sometimes it has for its object the removal of both bees and combs from the skep in order that they may tenant a frame hive, and then adverse conditions may need some care in preparing the stock

for the operation. In cool weather, and where honey has not recently been gathered, about twenty minutes or half an hour before attempting to drive, the skep should be inverted after smoking, in order that the bees may be freely sprinkled with warm, thin syrup. This syrup should contain not more than a pound of sugar to a pint of water (if thicker, it would be likely to glue the bees together), and should be made by boiling with vinegar, or some other acid, such as citric or tartaric, so as to convert the cane sugar into grape sugar (see Bee Foods), or the syrup will dry and crystallise upon the bodies of the bees, like so much chalk. Of this a gill will be sufficient, and, if the combs be tough, the skeps may be held so that the syrup may be poured into the cells of the several combs. The feeding and the excitement will raise the temperature, and greatly expedite our work. Indeed, drumming for twenty minutes upon a hive caught up immediately after smoking will not, usually, drive as many bees as two minutes will dislodge from one in proper condition.

In open driving, the skeps need not be of the same diameter; indeed, on one occasion, when on a visit where a few stocks of bees were kept, having consented to make an artificial swarm, I could discover nothing better to receive it than a lady's chip bonnet-box. The box was well scored inside, to give the swarm foothold, and in a few minutes the whole operation was, with perfect success, accomplished. A well-known writer on apicultural matters tells us that the bees run up to escape the distressing jarring of their combs ceaselessly kept up by beating

upon their hive walls. Were this correct, it is pretty evident that they would rather descend to the hive crown, where the combs are attached, and where, consequently, the jar is the least, and the relative distances of the combs not interfered with. I take it to be a matter of instinct, which does not alter its method although the circumstances under which it works are reversed. Frightened bees instinctively run *upwards*, in order to retreat from the edges and exposed portions of their combs, and reach their honey, and so save all they can of that wealth they dare no longer defend. We cheat them, in driving, by putting the honey beneath, while their unalterable instinct, forcing them upwards, brings them into the open, and carries them on until we have them suspended from the roof of our receiving skep as a swarm. If a skep or frame hive, in its natural position, be banged a few times, so as to vibrate the combs, the bees will be found above gorging themselves at the open honey-cells.

The inversion of the hive is no essential part of the operation, and, with the skep, the impossibility of removing its crown is the only impediment to its being driven *in situ*, as the following example will illustrate. One of our swarms, in 1871, built so irregularly in an ordinary Woodbury hive that the removal of any single comb was impracticable. In order to accomplish the re-arrangement of the interior, it was essential to lift out all the frames and combs in one mass, and this necessitated the previous removal of the bees. The crown-board (occupying the place of our present quilt) was taken off, the colony gorged,

and a Woodbury, containing frames only, and without its bottom board, placed upon it. A few minutes' rapping sent almost every bee into the upper hive, which, with its forced swarm, occupied the old stand, while the straightening process was in progress.

We have said that beating upon the hive from one to five minutes will cause the bees to ascend, but with very weak and poor stocks, or in cold weather, this time is often much exceeded; and sometimes, with a conjunction of the unfavourable conditions stated, the bees utterly refuse to leave. In this case, they may be got out by throwing, which must not, however, be attempted unless the combs are tough, and provided with cross sticks. The skep is held between the hands at the rim, the fingers within, and the thumbs without, when, by a decided downward jerk, most of the bees will be at once dislodged. Give them no time to recover their astonishment, but repeat the process, and, after three or four shakes, hardly a bee will remain. Of course, a sheet must be spread to receive them; and if a hive be placed on the side or corner of this, in about the position the stock occupied, the bees will enter and cluster, so long as new bees are being added, even if the queen be not with them.

It is, at all times, difficult to drive from hives but partially filled with combs, since the bees cluster in its unoccupied parts rather than leave; while the attempt must not be made with very young colonies, whose combs are so tender that breakage must follow the necessary beating. A caution is also needed against driving after hot days, when much

honey has been gathered, or this will commence to run from the combs so soon as the skep is inverted; while our jarring will so shake it out that the bees may be hopelessly glued together, from which cause not only may we fail in obtaining a forced swarm, but the colony will be damaged, and perhaps even the queen killed. Let the operation be attempted on the following morning, when the limpid, newly-gathered nectar will have considerably thickened by evaporation, and, further, the process of sealing—*i.e.*, the capping of the store cells with thin waxen lids—will have progressed during the night; while, also, the temperature will have dropped, making the combs less liable to collapse.

The great destruction of bees commonly attending driving competitions and similar exhibitions—such an unfortunate travesty of the humane system—is generally due to the bees being strangers to the place in which the operation is necessarily undertaken, so that all escaping, being irretrievably lost, gather into little knots representing those that, under ordinary circumstances, would retire to the decoy hive. Driving in the apiary, under usual conditions, hardly necessitates the loss of a single bee.

Let us now return to the question of making an artificial swarm from a skep, which, of course, is treated as just described. During the ascent of the bees, we watch carefully for the queen, whose presence is essential to the success of the operation. A quick, or, rather, an educated, eye will rarely allow her to pass unnoticed: but, if she has not been seen, while the great majority of the bees have already made

their ascent, detach the receiving skep and turn it up for an examination; and should her majesty not show herself, shake the bees sharply round, as in the operation of sifting, when they will roll over each other, like so many grocers' currants—the object of our search being, in all likelihood, thrown to the top, to be at once detected. The disposition to run upward still shows itself, and the bees, as they get opportunity during the disturbance to which they are exposed, commence to crawl (for they will not fly) up the sides of the hive and cluster thickly upon it, giving to the queen a hiding-place, of which she will not be slow to avail herself. Beat them down, therefore, by sharp raps on the outside of the skep, or strike its roof vigorously upon the ground to accomplish the same purpose. Repeating the operation a few times, we can hardly fail in discovering, if present, the mother, in spite of her attempts at concealment behind her bewildered children. The queen having been seen, place the forced swarm upon the old stand, and shake out the bees that have, in the meantime, returned from the fields to the decoy hive, when they will enter their new abode, and, finding their queen, will, with the rest, commence comb-building, as would a natural swarm. The old hive must now be placed on a new stand.

To the inexperienced there are two possible difficulties, about which a word or two of explanation seem requisite. First, finding the queen. Some are not quick at this, even after considerable practical experience, and such operators must depend on other evidence than that of sight. Nothing may be left

to chance, since the queen does not invariably rise during the driving, while her presence is absolutely essential to the swarm. If the forced swarm, being placed on the stand, remains tolerably quiet for the space of twenty minutes, or half an hour at most —the bees not rushing wildly in and out of the hive, nor running over it apparently in search of something—it may be concluded that they have discovered their mother, notwithstanding our failure. But if their excitement is great and, apparently, increasing, while the driven hive is quiet, the evidence is unfavourable, when either the driven hive must be again operated upon, in the hope of securing her, or the bees returned to the old stock, replaced in its original position, so that another attempt may be made on a future day.

The second difficulty is leaving in the old stock just the fitting number of bees for carrying on the work of the colony and raising queens. This is often most conveniently managed by arranging the stock and swarm with reference to their old location. If not more than half the bees had been driven when the queen was seen to rise, the old stock must occupy a totally new site, while the swarm is put in possession of the original stand, to which, from force of habit, many of the bees still left in the stock will come after their first flight; but if the stock has been driven very bare of bees, it is well to place the forced swarm and parent hive on opposite sides of the stand formerly occupied by the latter. The distance intervening between will depend upon the general arrangement of the apiary. Where the hives are compressed

into a small space, the two may be nearly in contact; but where they are widely dispersed, each may stand 3ft. or 4ft. from the old spot, with the object that the bees returning from the fields may be as likely to enter the one as the other. Should the stock appear to be getting more than the necessary number of bees, disguise it by some cover, or place it still farther from the old position, to which bring it nearer in the opposite difficulty. Where space is very restricted, these same effects may be produced by simply rotating the hives or bottom boards, so that the mouths are more or less changed with regard to the points of the compass. If the driven swarm is to be sent away, it should be packed as a natural swarm (page 136), and the stock will then occupy its old stand.

The bee-keeper who has sufficiently advanced to undertake the processes just described is not likely to look with favour upon skeps; and since these can often be cheaply purchased, they are not unfrequently used for supplying the population for a frame hive. The latter, handled upon non-swarming methods, will almost invariably give better results if the whole population of the smaller skep, together with the combs and brood, be put within, so that no actual increase in number of stocks occurs; and, indeed, converting two colonies in skeps into one in a frame hive, will often be found a most profitable arrangement; the process in these cases becoming that of transferring, which may be quite logically treated here, since it involves the making of an artificial swarm as its preliminary step. After the removal

of every bee that can be induced to depart by driving, we proceed to draw all sticks (if such exist), either seizing them by a pair of nippers at the projecting ends, and rotating them to detach them from the combs, or we minimise the destruction of bee handiwork by sacrificing the skep, simply cutting it in half, while inverted, by passing through its sides, and between the combs, a sharp dinner-knife. If we refuse, from notions of economy, to destroy the skep, honey-knives may be employed. Of these, two form a set—one, used to cut combs from the sides of the skep, and which a piece of straight hoop-iron, from 14in. to 18in. long, and ground to an edge at the end, may well replace; while the other is formed of an iron or steel rod about 18in. long and $\frac{5}{16}$in. thick, having 2in. at the extremity turned to a right angle. The latter part is formed into a cutting blade, the surface of which is horizontal when the rod is held in the perpendicular position. The first knife having performed its work of separating the combs at the sides, the second is brought into play. Having slipped it down by the side of the comb, it is turned so as to bring its blade into position for cutting from the hive roof.

Instead of these knives, I much prefer my home-made device, which consists of two thin, bluntly-pointed, wooden laths, sufficiently long to pass between the combs to the roof, while held firmly. Around these, when placed one on the other, a piece of tinned wire, No. 30 (the same as that used for wiring foundation), is passed loosely from points to ends, so that the laths can be held about 1½in. apart by draw-

ing the wire tight. The laths are passed down on opposite sides of the comb to be removed, the wire between the points cutting completely round it at one operation, in the neatest and most rapid manner; while the tension slightly imbeds the wire in the wood, so that it remains in position when the laths are put down awaiting their next employment. The removal of one comb accomplished, carefully lift it, and place it on a board greater in length and breadth than the frames to which we are to transfer. Place the frame over the comb, and, with a sharp dinner-knife, mark the size of the former upon the latter, so that, when trimmed, it will fit somewhat tightly, and as accurately as its size and shape will admit of—and it is desirable, rather than necessary, that the top of the comb as built in the old hive shall also be the top as we fix it, the cells inclining somewhat upwards. Keep the comb against one side of the frame, in order that a firm attachment may the more quickly be made, and fit in any good pieces of worker-comb that aid in filling out the frame, and these the bees will unite by newly-formed cells with a neatness that must be seen to be understood.

Thickened combs (see Fig. 75) should be shaved down, and drone-cells wholly rejected, or placed only in the upper part of the outside frames. Should the comb not be deep enough to fit down to the bottom rail of the frame, while no pieces can be economically added, it is necessary to put against its lower edge a strip of thin wood, about $\frac{3}{4}$in. wide, when two or three tapes, that ought to have been laid on the board before putting the comb down, are

passed round the frame and comb, or comb and lath, as the case may be, and securely tied. The board is now raised to the perpendicular, with the comb and frame upon it, when the latter is lifted by the ears and placed in the hive. Whilst treating the combs thus *seriatim*, it is highly important to keep the brood together, and, if their previous relative situations be preserved, better fitting will be secured.

The operation will be more easily performed, if a

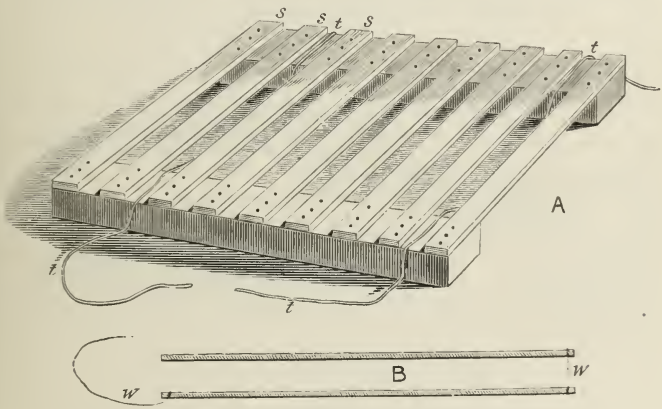


FIG. 68.—SIMPLE TRANSFERRING-BOARD AND STICKS.
A, Board—*s*, *s*, *s*, Slats; *t*, *t*, Tapes. B, Sticks—*w*, *w*, Thin Tying Wire.

few slats be nailed to cross-pieces, as in Fig. 68. The tapes (*t*, *t*) are laid in between the slats (*s*, *s*), ready to be brought up round the comb, before the latter is put into position. But those who do much transferring will find they are greatly facilitated by my transferring-board (Fig. 69). The operator places the apparatus upon a table—he standing opposite to its face A B—and now lays the comb, with its top towards himself, upon the sixteen rods A B C D, made

somewhat like the teeth of a toilet-comb. The marking and trimming are managed as before described, while the zinc tray (*tr*) catches the bleeding honey, which falls immediately through or runs down to the dripping edge (*de*) seen in the cross section (A, Fig. 70); while the edge of the tray (*tr*) allows the knife to be conveniently cleaned by scraping. The space beneath the board gives both hands an opportunity to act in concert from its opposite sides; and the tape (*t*)—some use lead wire—is now passed through,

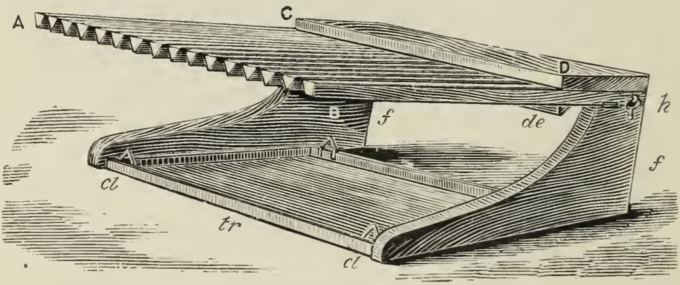


FIG. 69.—CHESHIRE TRANSFERRING-BOARD (Scale, $\frac{1}{8}$).
h, Hook; *f*, *f*, Feet; *tr*, Tray for Dripping Honey; *de*, Dripping Edge; *cl*, *cl*, Clips.

between the teeth and beneath the lath, or, if the comb extend to the bottom of the frame, beneath the bottom rail (*br*) and tied at *k* (B, Fig. 70), the angle of the top bar, as here a secure knot can be more easily made than at any other point. The frame is now pushed from the operator until its bottom rail touches the stiffener (C D, Fig. 69), when the apparatus is raised in front until it stands on its back (as at B, Fig. 70), leaving the comb and frame resting in the perpendicular position; the latter being then lifted by the ears, and placed in the hive.

When the transferring-board is out of use, the hook (*h*) being released permits of the folding back, at each end, of the foot (*f*). The tray is now turned face downwards upon the sixteen teeth, over two of which the clips (*cl*, Fig. 69) slide, and securely hold it in its place. Within the tray can be placed the brush, tapes, knife, and other requisites—no small convenience

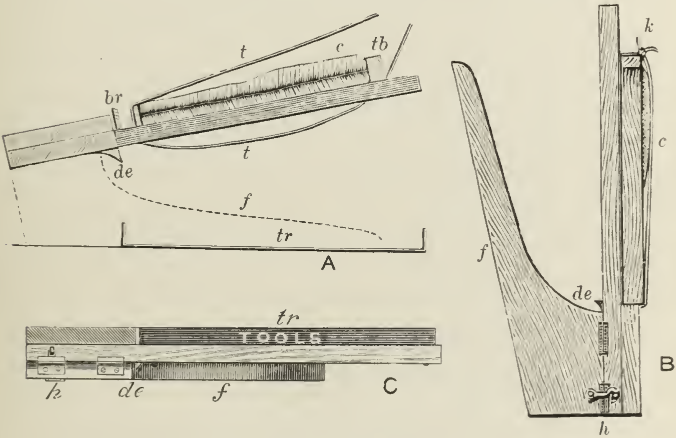


FIG. 70.—DETAILS OF CHESHIRE TRANSFERRING-BOARD (Scale, $\frac{1}{6}$).

A, Section, with Frame and Comb in Position—*tr*, Tray to Receive Falling Honey; *de*, Dripping Edge; *f*, Foot; *tb*, Top Bar; *br*, Bottom Rail; *c*, Comb; *t*, *t*, Tape. B, Transferring-board turned up to remove Frame—*k*, Knot in Tape; *h*, Hook. C, Transferring-board Packed up; other Letterings as before.

when the transferring is to be done at a distance from home. The thickness, when closed, is $1\frac{1}{2}$in.

If the comb is waved, it may be desirable to place a thin stick, $\frac{1}{4}$in. longer than the frame, on each side of it, and pass a small indiarubber ring over the projecting ends. This will keep the comb flat until the bees have made it secure. Indeed, it is the practice with some to use neither tapes nor

string, but to depend upon sticks (B, Fig. 68), which are $\frac{1}{4}$in. square, and $\frac{3}{8}$in. longer than the frame depth; these are, at one end, fastened together in pairs, by annealed wire, which keeps them about 1in. apart. Either of the transferring-boards illustrated permits of these being most readily slipped over the comb, while fastening the free ends is but the work of a few seconds. When it is found difficult to keep the midrib of the comb in the centre of the width of the frame, strips of lead or zinc are of service. These, bent over the top or side bar, press both faces of the comb by their ends, and firmly hold it until fixed. It will be impossible to prevent the destruction of some larvæ; but the beginner need not grow faint-hearted: repairs will be quickly executed in a wondrous manner; while the mortally wounded, and those killed outright, will be quickly removed, their juices helping to sustain the labourers in their arduous duties—the economics of the bee-hive never being trammelled by mere sentiment. The combs should be put together, and the bees so confined by a division-board that no unoccupied spaces may remain, room being subsequently given as the growing population may warrant. The work so far completed, the bees may be introduced, as explained at page 137. The honey set running during the operation will be gathered up, and will supply immediate needs; but great demands will be made for wax-secretion, to fill gaps and make attachments, so that it is usually good economy to feed slowly for a day or two; but, of course, circumstances liable to much variation must guide us. The stock, settling heartily to work—even

more heartily through the disguised blessing which has befallen it—will henceforth, in this particular, be treated as those of the rest of the apiary.

In forty-eight hours an examination may be made, when, if the combs appear firmly fixed, the tapes may be removed; but excessive haste is likely to be the precursor of disaster, as one comb falling will, like a tumbling skittle, knock down most of the others. Let the beginner who has concluded that artificial supports are no longer necessary, draw a sharp knife across the tapes, severing them upon the top bar of the frame, as it occupies its usual position; it may then be gently raised, the perpendicular being carefully preserved. The tapes, by a touch, can now be detached from each side, without giving the jar to the tender work so likely to lead to misfortune if the whole operation is carried out by the novice with the frame outside the hive. If the tapes be not removed, the bees will tease and fret them until they dislodge them literally fibre by fibre. Many years since, I had fastened in a comb by a string, and quite forgotten the circumstance, until, apparently, a piece of extremely thick chenille was observed, waving in a singular manner at the hive door. The chenille, as I approached, resolved itself into a dense chain of bees, most earnestly flying, while holding on to the string, which they had torn almost to fluff, had separated from their comb, and were endeavouring to eject altogether from their domain; success being only delayed by the string locking itself between the hive and the bottom board.

During any part of the honey-harvest, transferring

may be performed in the open; but generally a building is necessary to avoid the annoyance of robbers. Chilly weather is unfit, because the brood is likely to suffer, while repair is carried on tardily; but experience will enable the operator to undertake the work at almost any time. I have transferred as early as the 1st of March, and as late as the middle of November; but it is well to remember that very hot weather makes the combs so soft that they sink out of form, the lower cells being flattened by the weight of those above them. Four or five days after transferring, it is desirable to clean the bottom board, as a considerable amount of *débris* is thrown down in the process of repairing and refitting. Some would transfer without driving, simply clearing the bees by smoke from the comb to be excised, and then brushing down those removed with each comb in front of the new hive. Except with very weak populations, the majority would find ordinary driving less troublesome.

We must here note that Mr. Heddon claims a method of transferring, which he denominates "modern," as distinguished from the "old" plan just detailed. Mr. Heddon may have been the first to suggest the "modern" method in America, but it is certain that a substantially identical one was practised in England several years before he made mention of it. I find, by example, that I recommended it twelve years since, suggesting that the bees be placed on sheets made as explained on page 181. It is so simple and obvious that none could secure through it a reputation for inventiveness. The skep is re-

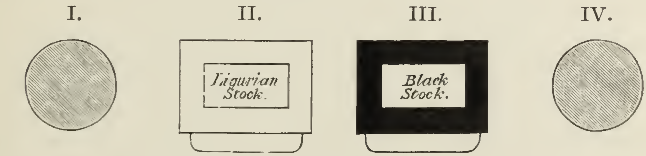
moved, and a forced swarm, together with the queen, driven and placed upon the old stand, in a hive furnished with a sufficient number of sheets of foundation. These will quickly be drawn out, giving the queen an opportunity for rapid laying. If we intend that, three weeks later, the present brood in the parent hive—then coverted into bees—shall be added to the forced swarm, we stand the parent and swarm close together, turning the former so that its doorway is somewhat averted from the old position. In twenty-one days all the brood will be hatched, save, perhaps, a few drones (which are twenty-five days between egg-laying and hatching). A second driving secures the bees and the young queen, which must be removed, and the bees united. The combs may now either be fixed in frames, or extracted and run down for wax. It is true that foundation gives, economically, such perfect combs that transferred ones seem ungainly, and hardly worth the labour involved in preserving them; whether their interim value warrants this is a question which each bee-keeper must determine for himself.

"*Three out of two*" is the title of a method of moderate increase which has very much to recommend it, and, where two or more hives are possessed, is decidedly to be preferred to any plan which, by removing a swarm, halves the colony at one operation. Early in the season, too, when we may fairly indulge the hope of securing fecundation for our new queens by special drones (see page 273), but when the hives, though prospering, are as yet none of them strong enough to retain an efficient working

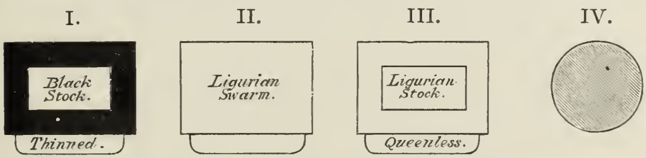
population, and besides spare a good swarm, this plan may be put into execution, since *every* bee is, by it, at command to people the new hive. On the morning of a day when the honey-gatherers are flying strongly, drive every inhabitant from the stock selected to supply the swarm, which place on the stand of the parent stock. The parent stock is now made to occupy the stand of a second hive, which, in turn, takes a new position. All the bees of the parent hive remain with the driven swarm. The bees in flight from the second stock people the parent hive, feed the brood, maintain the required temperature, and raise a new queen; while the second stock, though losing its foraging population, has sufficient young bees not yet engaged in honey-gathering to carry on its work. (This method is applicable to frame hives as well as skeps, if driving be replaced by shaking or brushing, as presently explained.)

Suppose, *e.g.*, a bee-keeper to possess a Ligurian and a black stock, and that he desires to favour the Italians at the expense of the blacks. By driving all the Ligurians, and placing their hive upon the stand of the black stock, which is carried to a new location, half the blacks become nurses for Ligurian brood, and for raising a Ligurian queen; while the black stock, by constant hatching within, will, in a few days, be as strong as ever, and, at the expiration of ten or eleven days, if previously well furnished with brood, may be itself swarmed (technically "forced"), when it will be placed on the stand then occupied by the first parent stock referred to, which will, in turn, go to a new position, thus losing the flying

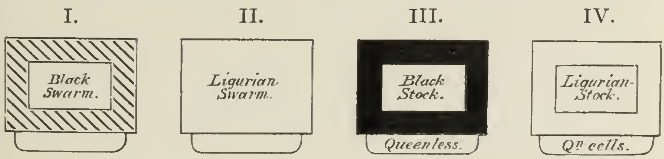
bees, which had been, as it were, lent to it until it had hatched out a sufficient number to be independent of their aid. To make the matter clear, let I., II., III., IV. represent four stations, of which II. and III. are occupied as below.



Then, after forcing Ligurian swarm—say, May 1—



And, after forcing black swarm—say, May 11 or 12—



One great advantage of this arrangement lies in this—that, at the expiration of the ten or eleven days after the first swarming, the Ligurian stock removed to Stand IV. will have finished queen-cells, only one of which will be required for itself; a surplus one may then be cut out and given to the black stock, which has just* lost its queen, and which will, in

* It is wise, unless we take the precaution of using a "Doolittle Cage" (which see), to delay inserting the queen-cell until the day following the removal of the swarm, or the queen-cell may be torn open.

consequence, have a breeding queen ten or eleven days earlier than if left unaided: in view of the enormous laying powers of the mother bee, an advantage, as before remarked, equivalent to a swarm.

We have now the opportunity, if possessed of other skeps, to repeat the operation upon as many pairs of these as there are ripe queen-cells at command, for each two made into three will require but one new queen; and if we have been wise enough to select for yielding our first swarm a stock which gave fine results the previous summer, we, by this step, not only, possibly, satisfy the swarming impulse and secure some increase, but also tend to improve the strain of our bees.

The queen-cells are frequently planted upon the lower edges of the combs, so that any one of them may be easily taken out, even from a skep, by cutting away with it, with a thin, sharp knife, or a piece of sharpened clock-spring rounded at the end, about a square inch of comb, while the bees are kept in check by a little smoke. There is some difficulty in inserting queen-cells into skeps, as they must be placed in the midst of the brood if possible. By separating the combs a little, one may be passed between them, and simply held by their grip, or it may be put in at the feedhole between the combs, room, if necessary, being cut for it. The position in which it stands is not material—it will hatch on its side, or upside down, unless inverted at an early stage—but the cell itself must be free at its extremity, to give the queen an exit. Queen pupæ are very sensitive to chill, so care should be taken in not exposing to cold the cells, which the

operator must also tenderly handle, as a pinch, especially near the end, is likely to fatally injure the soft-bodied grub. Indeed, it is undesirable, even with the most careful manipulation, to transfer queen-cells until near the time of their hatching, which may be known by the bees thinning down and roughening the cell at the end (page 154). This ripe condition is sometimes, though rarely, reached by the tenth day after artificial swarming; * but frequently we may have to wait to the thirteenth or fourteenth, watching carefully, or the objects of our solicitude may be destroyed through the most advanced princess escaping from a cell, overlooked at the time we were searching for such as were ready for removal.

Plans only possible with frame hives now demand attention. Let us suppose we have sold a swarm, and intend sending it packed in a skep. We may commence by quietly removing the frame hive some few yards from its stand, reversing the position of its mouth to prevent its being recognised by its proper inhabitants; but since, with strong colonies, even the expert is sometimes baffled in finding the queen, it is prudent to secure her ladyship as the first move. Taking a dome cage (see "Queen Introduction"), and a card, we lift the quilt, using no more smoke than is absolutely necessary; for disturbance sets the queen on the run, drives her from the brood-nest, and decreases our chance of seeing her quickly. Having pushed the division-board on one side, so that our frames may be moved laterally, we first run

* Queens so rapidly produced are of inferior quality (see "Queen Raising").

over those of the brood-nest. Lifting out a side one, carefully raising it in front of the eyes, and scanning the side towards us unsuccessfully, we bring the frame from position 1 to position 2, Fig. 71, by lowering the right hand and raising the left until the top bar becomes perpendicular. The frame is now, by a gentle swing, soon acquired, made to take, upon the ears held in our fingers as a perpendicular shaft, a half-revolution towards the right, which brings it into position 3, and thus the opposite face of the comb is presented to us. Reversing the up-and-down motion of the hands restores the top bar to the

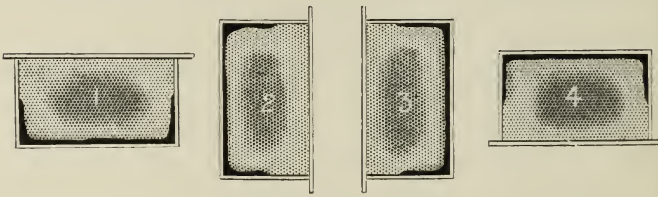


FIG. 71.—THE FOUR POSITIONS TAKEN BY A COMB DURING EXAMINATION.

horizontal (position 4), with the comb inverted, but yet perpendicular, as we have kept it from the first, so that its weight in no way tends to loosen it from the frame. The previous movements, in an inverse order, return the comb to position 1, when we replace it in the hive, but as far from the next brood-comb as interior space will admit, lest the queen pass at once to it, and so elude us. Continue the search, and, when the queen is found, either hang the frame upon a comb-stand—of which the most portable form is seen in Fig. 72 (it is simply hooked on the side of the hive under operation, and requires caution in

its use, either in chilly or in exceedingly hot weather)—or hold the frame by one ear, and, with the hand at liberty, pick off the queen, seizing her by the roots of the wings, for the thorax of a queen is exceedingly strong and tough, but the abdomen must on no account be subjected even to the most tempered pressure. The frame, lowered by the one hand holding it, may now easily be stood in the hive diagonally—*i.e.*, one corner up—or, by a little practice, the hand retaining the queen can aid the other by its little finger, when the frame can be at once replaced properly. The queen is now held up by the finger and thumb under the dome of wire, and released, the palm immediately forming a floor,

FIG. 72.—COMB-STAND OR REST.
h, *h*, Hooks to pass over Hive Side; *b*, *b*, Brackets to support Ears of Frame.

for which the card is at once substituted. The State prisoner is now placed on the top bars of the frames, the quilt readjusted, a little smoke blown in to induce the bees to gorge, and the hive closed, after which it is turned half-way round and removed four or five yards away, where it must await the completion of our arrangements.

We next place on a stand (*st*, Fig. 73), as nearly as possible the height of the hive mouth, a board (*sb*) and skep (*sk*), raising the front of the rim of the latter on a stone or small block, which

should take exactly the position of the mouth of the frame-hive before its removal, because to that spot the bees will fly with an accuracy which is truly surprising. Going to the stock, we lift back the quilt with great caution, lest we disturb the queen-cage and set the prisoner free. The excessive space

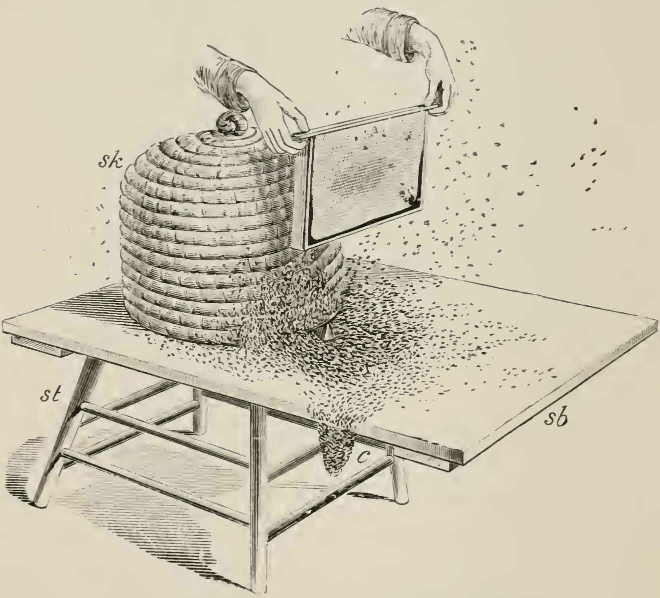


FIG. 73.—MAKING AN ARTIFICIAL SWARM (Scale, $\frac{1}{12}$).
sb, Swarming-board; *st*, Stand; *sk*, Skep; *c*, False Cluster.

left between two of the frames has caused the bees there to gather thickly, so that we secure at once a considerable number. The frame, now held by the ears, is sharply jerked downwards in front of the skep, as we stand behind, so as to be out of the way of the bewildered hummers on the wing. The bees imme-

diately drop in great part from the comb, and a second shake finishes the work quite sufficiently. Returning to the hive, we lift the queen, and release her amidst the rapidly-entering throng. So soon as she disappears under the edge of the straw, all anxiety respecting her is unnecessary. The process of throwing is continued with other frames until sufficient bees have been obtained to form the swarm. Regulating the frame distance in the parent stock, adjusting the dummy, and covering up snugly, so far completes the process, which should not, from the beginning, have occupied more than a quarter of an hour.

Two cautions seem requisite. First, if nectar has been gathered freely into the frame hive, jerking off the bees is inappropriate, as the thin fluid is thus thrown from the combs, and, becoming rapidly viscid by evaporation, may gum the bees together; while newly-built, tender combs, would not bear, without fracture, the strain which jerking involves. In these cases, brushing must be adopted, the use of a feather or goose-wing being constantly recommended. I greatly prefer a painter's large duster, but it must be rightly used. Rapidly whisking the very ends of the hairs over the bees, in the direction in which they are desired to drop, clears them off without irritation, in a manner I have never accomplished with a goose-wing. If the side of the brush be used, or if it be applied nervously and slowly, the bees get entangled, and, by buzzing, not only show their own anger, but excite that of the rest. Mr. McKnight says that he employs a tuft of long grass for this purpose with most satisfactory

results. The second difficulty could only perplex the beginner. Bees constantly play at follow-my-leader, for they are to the manner born; and should a few, during the general inquiry for the lost home and lost mother, run, as though in the secret, to the side of the board, others follow, until quite a contingent may form a false cluster (*c*) under its edge. Left to themselves, they by degrees become conscious of their mistake, and, after showing some restlessness, turn their heads, and go off to join the majority. These false clusters never need be suspected of containing the queen, if she has been seen to enter the skep, for her rude awakening to the fact that times are troublous will so well teach her to love darkness rather than light, that she will on no account leave the skep for the exposed surface of the swarming-board.

If the error of the frightened insects be observed in time, shovelling up the stream on to a card, and throwing it into the hive opening, will nip the nuisance of wrong information in the bud. Sometimes, the weight of the cluster grows until the hold the topmost bees have upon the board is insufficient for the weight, and all tumble; when a stick or lath, having one end placed near them, on the ground, and the other leaning against the board, will supply ladder-way, by which they will quickly regain the hive.

If time presses, we may expedite the entrance of the bees by the card and a little smoke, when the packing will be accomplished as described on page 136. The old stock is immediately returned to its

position, giving an opportunity to the stray bees to re-enter ; and the few youngsters crawling on the ground will almost all be saved by the use of the lath as before.

The skep, although light and handy, is by no means all that can be desired for the successful transit of bees (page 136). I recommend, with the fullest confidence, a form of box (Fig. 74) which I have never known to fail on the longest journeys to be taken within the United Kingdom. It needs but little explanation. The swarming-board (*sw*) is used as

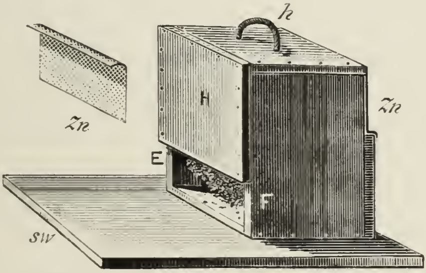


FIG. 74.—SWARMING-BOX (Scale, $\frac{1}{12}$)
sw, Swarming-board ; *h*, Handle ; *zn*, Perforated Zinc.

before, while the mouth (E F) stands in the place and stead of the mouth of the old hive, of which H replaces the front. A stout cord (*h*), having knots inside, serves as a handle, and keeps the right side up, while it furnishes good attachment to the cluster hanging within. The perforated zinc above and below gives thorough ventilation, which can never be closed even if the box is put on its front or back. After the swarm has been made, and has clustered as seen in the Figure (weighing being easily possible even before this), the front zinc is tacked on, when

the box is turned down on its face, and the bees fed with rather thin syrup, by standing one or two inverted bottles on the back zinc. Each pound of bees thus provided will take up about two ounces of syrup, scarcely more than one-third of an ounce of which will be lost during a twenty-four hours' journey. This feeding makes up for the full gorging of natural swarms, and adds much to the staying power of the bees. At their arrival, the box is stood down, to permit the cluster to form, when the zinc is prised off, and the whole thrown out at the door of their new home, as in cases already considered. A box fifteen inches wide, eight inches from front to back, and a foot high, having zinc pieces four inches wide, will carry five pounds of bees in any weather in our climate, and is superior to those constructed entirely of wire-cloth, as used in America, not only because of its greater ability to sustain rough handling, but for the reason that the latter, accidentally stood in a hot sun, expose the bees to baking to death, while the openings on all sides prevent the establishment of a direct air current, as secured by the box I recommend, for the bees, hanging exclusively against the wood, leave the zinc clear for the work of the fanners.

It is a very just, and, happily, a now common, practice to sell bees by the pound; for the size of a swarm, especially if made artificially, is almost as indefinite as that of the proverbial "piece of chalk." An open box, suitable to travelling bees, has the shoot of a very large, smooth funnel, oblong in cross section, placed within it, when the whole is stood on a

balance, and the weights adjusted so as to turn when the quantity of bees desired has been added. These are jerked or brushed from the frames into the funnel mouth, when they slide to their destination. In this case, the queen is best given at the last, by lifting a corner of the perforated zinc cover. The bees need not all come from one stock, and the queen may be an entire stranger to every worker. Being fastened up, they soon discover that they are queenless, broodless, and imprisoned, and commence their lamentations by a loud and characteristic roaring buzz. Any queen may now be dropped in, and she will be received as the harbinger of hope. When the heterogeneous colony is liberated on new ground, it goes to work as would a natural swarm. Mr. Simmins, who has done so much to improve and simplify queen introduction, is, I believe, the originator of this very useful method.

In order to give the purchaser confidence in the strength of the swarms offered, some dealers have quoted 20,000 bees as a guaranteed number; but surely this has been done under a misapprehension, continued because of the difficulty actual counting involves. It has been already stated (p. 212) that bees of distinct races vary considerably in weight, but the amount of material contained in the digestive tube, and the state of the honey-sac, may cause the number per pound to differ much more widely. I found 10,200 individuals, brought to starvation, weigh 1lb. only, while the larger of the dark-coloured bees, gorged as at swarming time, weigh 1lb. per 3000—the smaller, yellow races running up to 4500 or even 5000 per pound; and these bees will yet take more food when it is

offered them. Ligurian hybrids, as swarming bees, usually run 3500 to the pound, which may be regarded as the average. From this we find that, when allowance is made for the small number of comparatively heavy drones mostly accompanying the swarm, 7lb. weight may only contain the guaranteed number of individuals, while, in average cases, more than $5\frac{1}{2}$lb. will be required. In the face of this, the dealer who gives his customer 4lb. of bees for a swarm may be accounted not only just, but even generous.

Should we, in making swarms in our own apiary, and for our own use, be dealing with movable-comb hives whose frames are, unfortunately, not interchangeable, we are forced to proceed somewhat on the previous lines. The hive to receive the swarm may either have its mouth opened to the fullest extent, with the swarming-board simply fitted up under the alighting-board, or it may stand propped up without its bottom board, where we find the skep (Fig. 73).

We at length come to consider plans requiring interchangeability of combs—*i.e.*, uniformity in size of frame—a condition more or less obtaining in all well-managed apiaries. Here we have every scope, and the possible variations are endless, while it would be difficult to unreservedly particularise any one of the latter as the best, since surrounding circumstances, our faith in the facility and safety with which queens may be moved from stock to stock, and our methods of raising our queens, must often greatly influence our choice in the matter. All that has been previously said about the advantage of obtaining ripe queen-cells for insertion

into artificially-swarmed stocks will be here remembered; but in every apiary of fair size, managed on the movable-comb principle, laying queens, and not queen-cells merely, should be raised in advance, so that, as a rule, neither part of the colonies we swarm or divide need suffer, even for twenty-four hours, the losses involved in queenlessness. Hereafter, too, we must learn that queens of the highest type can only be secured by certain precautions, which are impossible when stocks are allowed to re-queen themselves as best they may; but experience will show that, in practice, even the most expert cannot invariably accomplish all that theory indicates as desirable, and that, as in many other matters, we must rather be content with what we can, than what we would, achieve.

The proprietor of a single stock, which must first be very strong, can hardly do better than proceed thus: On the morning of a fine day, let him take one, or better two, combs of sealed or well-advanced brood, and place them, with the queen, in a new hive, adding on each side two frames of comb, or, if these are not possessed, foundation, closing up the five or six frames with a division-board, and placing the whole on the original stand, while the parent goes to a new station, which need not be distant if the hive receive a half-rotation. Each bee that has already become a forager will, at her first flight, return to her accustomed place, and join the new-made colony, which is thus sufficiently strengthened to enable it to make progress. The gap left in the parent stock by the removal of some of its frames must be closed by pushing the remaining ones together, to conserve

the heat of the brood-nest; and it will be wise to contract, by a division-board or dummy, rather than add new frames of comb or foundation, unless the stock had been previously overflowing with bees.

In the absence of a laying mother or sealed royal cell, the orphans must be left to their own devices, involving loss, which may, however, by a little trouble, be very considerably reduced. The principle involved is important, and should always be borne in mind in the management of nuclei (see "Nuclei"). The parent stock rapidly grows strong by its brood hatching, this process continuing for three weeks, at precisely the same rate as if the old mother had suffered no disturbance; but in three days, the last egg laid by her before her removal having hatched, the amount of unsealed brood begins to diminish, and on the ninth day none remains, so that the younger bees, which should devote their energies to nursing, are reduced to enforced idleness. On the other hand, with proper attention to feeding—should a restricted honey flow make it necessary—the queen will soon have deposited all the eggs for which she finds accommodation, or which can receive attention; for, had we not meddled, she could have kept *all* her nurses busy, but the greater part of them are now in another hive. The mother, thus limited, ceases to be of advantage to her colony until brood by hatching has once more supplied her with empty cells. This waste of energy, due to lack of nurses in one stock and lack of eggs in the other, is clearly remediable by transferring, every few days, a comb of eggs to the parent, and returning for it a comb of hatch-

ing brood and stored honey. We thus keep the queen up to her work, and the nurses of the parent stock busy—a process by which *both* colonies are made much stronger than they could be without it; and, by the time the young queen is laying, instead of her hive being utterly broodless, so that its population keeps shrinking for three weeks—a fact which almost always makes a stock useless for honey-production—she is surrounded by brood in all stages. For these great advantages, the old queen has to pay the insignificant penalty of a little greater strain upon her egg-producing powers. Two small colonies, having one queen between them, can in this way often be made as well off as though they had two.

"*Making three out of two*," previously described as applicable to both skeps and frame hives, may, with the latter, advantageously take the following slight modification: On a fine day, when the bees are flying briskly, remove half the combs, one by one, from a colony occupying, *e.g.*, Stand II., page 253; which combs, in my opinion, especially if we intend to re-queen immediately, should embrace half the store and half the brood-nest of the hive under operation. Shake or brush off every bee, placing the combs in order in a new hive, and then fill up, in both cases, by combs or foundation. I have frequently seen the shaking cause much disorder, and the loss of many bees, the combs being jerked over the tops of the exposed frames. Instead, by removing the dummy altogether, or pushing it well on one side, secure a gap of 2in. or so. Then, in this gap, raise the frame, by the ears, 5in. or 6in., and bring it sharply down,

making the hands act as stops, by striking on the edge of the hive side, so that the frame does not reach the bottom board by a handbreadth. The bees fall to the floor, are not crushed, and are all, young and old, within. The few stragglers, and those on the wing, flying to the comb, may be brushed off as we are conveying it to its new resting-place. The stock on Stand III. is now carried to a fresh site—say, Stand I.—while the hive containing the bee-less combs and brood takes its place. The flying bees of the removed stock provide, as in cases before noted, the working population, which will, if need be, raise a new mother. It has been* advised to here cage a spare fertile queen, which may be liberated in thirty-six hours. This plan may, and would, succeed in conditions where scarcely any plan could fail, viz., in continued favourable weather, and during a honey flow; but in our uncertain climate neither of these can be calculated upon. If the sky become overcast, and the flight from the removed stock, consequently, sluggish, new contingents of bees will join from the removed stock during, possibly, a week, rendering the introduction of the queen most risky. I would immensely prefer adding the queen from the removed stock, which, having lost its old bees, gives the most favoured conditions for queen-introduction by caging, a system which I no longer follow, using instead of it the Simmins method. I should simply introduce direct my new queen at night, with the most perfect confidence that she would be duly accepted (see "Queen Introduction").

* "British Bee-keepers' Guide Book," page 85.

A still more gentle increase is often of the highest service. Take one, two, or even three combs containing brood and honey, from several stocks, until sufficient are obtained to comb a hive, shaking or brushing the bees off, as before, at their several stands. Place the hive containing the collected combs on the stand of a vigorous stock, from which, for reasons

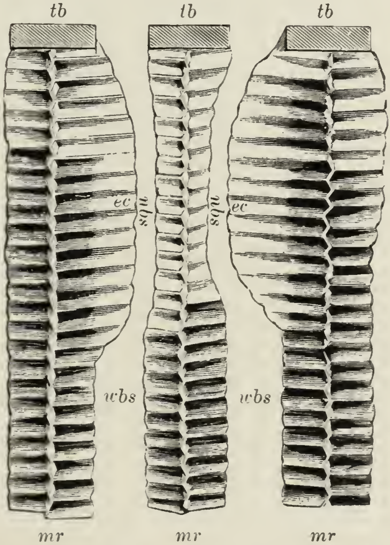


FIG. 75.—CELLS EXTENDED UNDULY (Scale, ½).
tb, Top Bar; *mr*, Midrib; *wbs*, Wide Bee Space between Brood-cells; *nbs*, Narrow Bee Space between Honey-cells; *ec*, Elongated Cells.

previously given, I recommend the queen to be transferred, so that she does not change her station. Re-queen the removed hive in the evening. The gaps left in the stocks supplying the combs may be filled by frames, preferably fitted with foundation, and so placed that combs stand between them, when they

will be very quickly drawn out. It is extremely desirable that these combs are either filled with brood to the top, or that the store over the brood be sealed. If they consist, in any part, of open honey-cells, these are often most annoyingly elongated, as at *ec*, Fig. 75; for, as honey is brought in, the cell-wall is made to grow, and so encroach upon the space the comb constructed upon the foundation ought to occupy, the cell-mouths of the facing combs here only giving sufficient accommodation for a single layer of bees. The cell depth for larvæ is a constant quantity—a bare $\frac{1}{2}$in.—and hence always leaves the space for the foundation to be fully drawn out. As brood is extended, the temporary difficulty will work its own cure: the lengthened honey cells will be cut down, and the shallow ones deepened; but this may be expedited by cutting back the excess, and placing the central comb of the Figure between other two. Inversion of the central frame, if eggs have been deposited beneath, will make the cure absolute from the beginning. The frames should be placed a full $1\frac{1}{4}$in. from centre to centre, whether foundation be given or not: in the latter case, the building of drone-comb will be thus checked.

The last method of swarming of which anything need here be said is called sometimes "nucleus-swarming," and differs from the preceding, in that the bees are brought to the new queen, instead of the new queen being introduced to the bees. Small colonies are established, usually on one frame of brood and two of store, and to each of these a selected queen-cell is given. When the queen, having been fecundated, begins to lay, her colony, by

changing places with a strong stock, and receiving combs of brood, or some similar device, is built up to full strength. I cannot agree with those who describe this plan as "by far the best system." It is one of the best, but no more. Nuclei should frequently be in course of building up soon after their creation; and so complete is the mastery we now have over queen-introduction, that it is often much more economical in time, to remove the queen when ready to be utilised, under one of the plans previously sketched, and then to give another queen-cell. The nucleus, aided by one or two frames of eggs, will be of full strength by the time the second queen is laying, and thus ranks as a stock without further disturbance. The full discussion of this question would be premature: it must now be left to be treated under "Queen-raising," to which the reader is referred.

Typical plans are now before us, which need no extension, although they may be varied almost *ad infinitum*, the intelligent bee-keeper constantly finding some specialty inviting a departure from stereotyped courses; but if tempted to experiment, let us remember that artificial swarming will not be successful unless it conform to *all* the conditions made necessary by the instincts and economy of the bee. The earlier worthies, in ignorance of some of these, were landed in discomfiture—*i.e.*, Huber (p. 45) divided his colonies into two, one of which was necessarily left in an orphan condition; he then gave, to each half, vacant frames, in which to build comb equal in amount to that which had been removed. As it is an instinct of the bee to build drone-comb

exclusively while queenless, or possessing only an unhatched queen,* one of the hives would be half filled by that which, normally, can be used solely for store, or for raising a horde of useless consumers. If this stock be a second time divided, and the half containing the drone-comb be also left queenless, extinction of this section of the colony is certain, queens being occasionally able to lay worker eggs in drone-comb notwithstanding; for, probably, they would not even possess the means of raising a new queen. Foundation enables us to commit to queenless bees the task of comb-building, since the size of the cell is not left to their selection.

For the benefit of the more enterprising of my readers, I append a few general principles, most of which were originally given in my "Practical Bee-keeping," about twelve years since, and by which the experimentalist may do well to test any plan before putting it into execution.

1. No swarming to be attempted before drones are rather numerous, or at least before patches of drones have been some days sealed. The old stock loses its queen, and the drone will be needed for her successor in about twenty-three days. The drone is sealed sixteen days, and is impotent until twelve or fourteen days old; he must, therefore, be sealed about seven days before the egg to produce the queen was laid if he is to be in time for service. Exception: When we have a fertile mother to give to the old stock.

* So soon as the queen leaves the cell, the bees start worker-comb. This has been denied; I have proved it by many conclusive experiments.

2. Drones, as well as queens, should come from selected stocks, and may be obtained early by working such stocks into strength by giving brood, feeding, and placing a comb of drone-cells in the centre of the brood-nest. The feeding should be constant, or drone-eggs may be laid and destroyed more than once.

3. Selected drones and selected queens should, by preference, come from distinct mothers (if two such, of high quality, are at command), or they will not so willingly mate ; and possibly, unless this condition be observed, bees of the highest energy are not obtainable.

4. No swarming should be undertaken in chilly weather, or when honey is not abundant : the swarm has no capital, and an empty house. Unless it obtains large supplies, it cannot build comb, and is liable to starve. Exception : When we feed constantly, or supply stored combs to the swarm.

5. Comb-building must not be left to a colony with an immature queen, or drone-comb only will be constructed until she leaves the cell. Exception : When full sheets of foundation are supplied.

6. Although a natural swarm may be placed in any position, and the bees will keep to it, a driven swarm must occupy the old stand, or be sent to a new locality, not less than a mile off. I have known of drones returning four miles. Exception : When we confine the swarm to its hive, in a dark room, till the third evening, providing ample ventilation, and giving sweetened water ; the bees will then remain wherever stood. With many stocks, results nearly as satisfactory may be obtained if they be thoroughly

aroused and frightened, both by jarring the hive and giving heavy doses of smoke, and then leaning a board against, or hanging a red cloth over, and a few inches in front of, their flight-hole, so as to arrest their attention, and cause them to mark their location when taking wing.

7. Driven bees, or any deprived of their combs, if left on their proper stand without a queen, will disperse amongst neighbouring hives, although their stay may be lengthened by disturbance, and adding more bees occasionally. Exception: If a piece of comb containing unsealed brood be given, the bees will not desert their hive.

8. Close partially, and according to circumstances, the mouths of stock hives that have been forced (*i.e.*, swarmed); they are relatively weak, and are likely to suffer from chill; they are also queenless, and are liable to be attacked by robbers.

9. If, from an oversight, a stock is left too bare of bees, it should be fed with sweetened water, and may, with the precautions mentioned in No. 6, be completely confined to its hive. In extreme cases, it should be placed in a warm room, but even then many of the young larvæ will die from neglect.

10. Swarm from your best stocks (*i.e.*, those giving what you most desire): this is a golden rule, and too often forgotten. Remember, you thus get a good queen for the swarm, and her qualities will be continued in her successor in the stock. Raising queens from weaklings that seem incapable of anything better, is reversing Nature's law that the fittest alone shall survive, by perpetuating the progeny of an effete

queen, and keeping the apiary under a star of ill omen in consequence.

11. Nothing tends more completely to profitlessness than prolonged queenlessness during the spring laying. If combs of eggs be given at intervals, this statement does not apply.

12. Honey-production and rapid increase cannot coexist. A mania for the making of swarms has, in its results, disgusted more young bee-keepers than all other causes of disaster put together. The manufacturer of weak colonies has usually to pay for their maintainance in the summer, and mourn their decease in the spring; so that, instead of profit, he loses his money, and his bees into the bargain.

The greatest difficulty of the bee-master is yet to be studied; for it is not in multiplying his colonies, but in preventing their multiplication, or in controlling absolutely the how and when of their increase, at the same time that he keeps them all at their highest strength, that he can best vindicate his title as an expert in the art; while by no other means is it possible for him to attain distinguished success in honey-production, and emphatically so if this honey is to be sold in the comb. Advice as wise as it was quaint was given, many years since, by Mr. D. A. Jones, in my hearing, at a little private party of bee-keepers, in reply to the question, "What do you think the most important rule as affecting profit in the management of our stocks?" He said at once, "Keep as few as you can." Supplying the ellipsis which was conveyed by the smile and the twinkle of the eye, the reply would run, "Keep your bees in

as few colonies as you can," which tersely gives the very kernel of all that can be said respecting success, if honey-production be our goal. The prevention of swarming has been, and still is, the bee-keeper's ideal, and therefore, again and again, so-called swarm-preventing hives have been declared, by their makers, to deserve the title conferred upon them; but if their virtues in this respect depend, as is usual, upon their great size, they are, on that very account, valueless to the practical apiarian, as we shall presently see.

Hives, it cannot be denied, may, by their structure, hinder or aid the bee-keeper, but none can by themselves secure the wished-for result: they are but instruments, and if swarming is ever to be successfully controlled, it must be by the exercise of wisely-directed management. The whole of the conditions which affect in any way the bees in relation to this matter need to be considered, and amongst them the influence of the queen upon her colony must not be overlooked. Casts, as already stated, carry with them a young queen, and, as a result, very rarely build any drone-comb the first year. With this must be associated a second fact—that casts in our climate practically never swarm within the same period. On the contrary, first swarms, having at their head the old queen of the stock whence they came, commonly build, if unprovided with foundation, considerable patches of the larger cells, while their swarming during the season of their issue (technically, maiden swarming), although not quite common, is by no means rare. Making due allowance for the fact that casts are later than first swarms, it is still clear that

colonies having old queens are far more likely to be seized with that disposition to colonise called the swarming impulse, than are those headed by young mothers. We have, then, in giving, as far as practicable, young queens to our colonies, a method of reducing swarming in the apiary.

High temperature and insufficient ventilation predispose to swarming. The remedies here are both obvious and easy of application—shading on the one hand, and providing ample room for exit and entrance on the other, being all that is necessary, as the bees, by a system of fanners stationed not only at the hive mouth, but arranged in the interior, establish currents which, however extended their home, ventilate it as effectually as the best-managed coal mine can be by its up-cast and down-cast shafts.

The major cause is, however, want of room, for bees are not infrequently *driven* to swarm by their hive becoming so filled that their brood-nest is alone left to receive the incoming honey. Straw hivists have long known that small skeps produce more, and earlier—although, of course, smaller—swarms than large skeps; and in frame hives, if store is coming in abundantly, swarming may almost always be induced by contracting the space the colony is allowed to occupy. For, so soon as the combs are filled with brood, eggs, pollen, and honey, queen-cells are commenced. It is true that the behaviour of bees, even of the same race, is not quite uniform, and that occasionally it is impossible to explain their doings. Sometimes, *e.g.*, they refuse to leave, but unmistakably indicate their need of greater space by

building comb outside their hive; and but few bee-keepers of experience have not seen it in porches, under stools, between skeps and the wall, and such like places: while, in rare instances, colonies will swarm persistently with their hive only partially furnished with comb. Notwithstanding such infrequent and anomalous cases, giving room within the hive, in advance of the requirements of the bees, may be broadly stated to prevent swarming. It must be given in *advance*, because the future is the child of the past, for, if the swarming impulse already possesses the colony, while their drones are hatching and their queen-cells are started, swarming becomes, in a measure, forced, and the enlargement of the hive will not prevent it.

If we are working for extracted honey (see Extraction), the problem is a comparatively easy one, for the laden bees can always have abundant accommodation provided for them; so that the brood-nest never need be choked by store, while the number of combs it is allowed to occupy is not very material; but the details of the method must be left until Honey becomes our subject. In working for comb honey the case is far different. If the hive be extremely large, the brood-nest and honey-store together only fill it, and, practically, get mixed up together, while the supers are untouched. If the hive be small, and the brood-nest contracted, the conditions which induce colonisation are soon reached, and much trouble, delay, and loss may result. Adding sections at the right moment, and replacing filled boxes by empty ones as necessity required, perhaps, in most cases,

prevented the rise of the swarming fever; but none pretended—even the most accomplished—to achieve anything like uniform success, until Mr. S. Simmins last year announced "an original non-swarming system," adapted to hives in present use, based upon purely natural principles, and resulting in "a total absence of any desire to swarm." If this announcement be sustained by experience, it is hardly possible to exaggerate its importance. The author of the system has subsequently introduced a hive in which he has endeavoured to give the fullest facility for the application of his method; but at present let us leave this out of view, and endeavour to understand the principle involved. About a quarter of a century ago, Mr. Pettigrew, a most conservative straw-hivist, wrote: "Can bees be prevented from swarming? Yes, by the use of ekes; and what are these? Additions or enlargements from below. Hives are eked by riddle-rims, or hoops made of four or five rolls of straw, of the same description as those in a straw hive, and the same width as the hives raised by them. These ekes are fastened to the hives by nails or staples going into both, and the junctions covered by any kind of cement or paste." Here, then, is an old statement somewhat like Mr. Simmins' (although not in the smallest degree invalidating his claim to originality); and, if examined, they will be found to mutually illumine one another.

At A, Fig. 76, we have the section of the filled skep (*sk*), raised on its eke (*e, e*), by which, according to Mr. Pettigrew, swarming would be prevented. The brood-combs which *were* finished have become by

eking incomplete, and this, according to Mr. Simmins, accomplishes the object, for he says *: "*No colony in normal condition attempts to swarm unless it has all its brood-combs completed.*" To this undoubtedly correct principle, which is practically invariable, I venture to add a second, which does much to explain the first: That no colony in normal condition will swarm, if by so doing it must leave the old colony

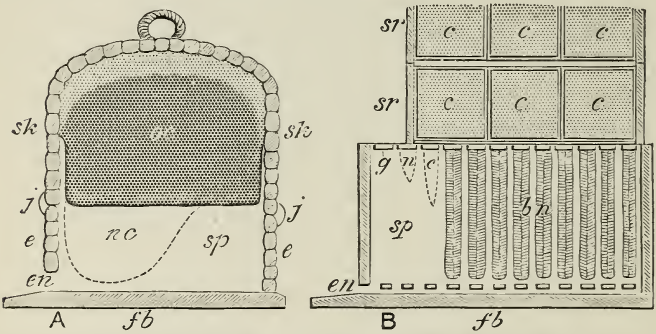


FIG. 76.—ARRANGEMENTS TO PREVENT SWARMING (Scale, $\frac{1}{12}$).

A, Straw Hive in Section—*sk*, *sk*, Skep; *e*, *e*, Eke; *j*, *j*, Joint; *en*, Entrance; *fb*, Floor-board; *oc*, Old Comb; *nc*, New Comb; *sp*, Space Unoccupied.
B, Ordinary Frame Hive, arranged upon the Simmins System—*g*, Guide: *nc*, New Comb; *sr*, *sr*, Section Racks; *c*, *c*, Comb; *bn*, Brood-nest; others Letters as before.

unable to defend its entrance. If a small swarm be put into a large hive, it invariably so stations itself that it can defend its hive-mouth in weather when other colonies can fly (see Fig. 5 and page 34). In the roof of Great Hadham Church, five or six colonies were located, and the arrangements made by these unfettered bees I thought peculiarly instructive. They had built between the rafters, and went in and out

* "Simmins' Original Non-swarming System," page 9.

where the slates overlapped the gutter, so that their entrance was above; and here their combs had undoubtedly been commenced, and then run back to the distance of 3ft. or 4ft., by which the defenders were, from the first, close to the base of their operations. This instinct constantly manifests itself, and every observant owner of frame hives must know that at all active seasons bees keep up a loose string of defenders from the entrance to the main body.

At B we have an ordinary hive arranged according to Mr. Simmins' plan, the brood-nest (*bn*), just before the honey-flow commences, or before drone-cells are capped, being limited to eight or nine frames; and these are kept at the back, while, next the entrance, frames carrying ¼in. starters or guides (*g*) only are placed. Here, as before, we have an opening next the entrance, and a possibility on the part of the bees of extending the brood-nest, and so an entire absence of a desire to swarm. But resemblance here ceases. By referring to the skep, we find that the new comb (*nc*) will be first extended next the mouth, and when this is completed to within a bee space of the floor, swarming may occur, notwithstanding the unoccupied space (*sp*) behind. In B, in extending the brood-nest, the frame next it—*i.e.*, the one farthest from the entrance—must be first built out, and then the next will follow; while the combs must be constructed from the roof downwards, so that the entrance is the very last point reached; and this gives the bee-keeper time to appear upon the scene, and utilise the constructed combs for his sections, as hereafter explained. In the skep, as the cells are multiplied the

queen descends and occupies them with brood, while honey is carried above, and stored in the old brood-space—so that run or extracted honey is, after all, alone produced. In the Simmins system the new combs are not for the queen, but are carried aloft, as we just now said, to the sections, so that they may *naturally* receive the honey. Curiously, by this device, the bees build combs for brood, and then store them with nectar; while, stranger still, as most would regard it, the bees are, by giving combs in their sections, so encouraged in storing that they there complete the comb honey, and leave comb-building near the entrance comparatively neglected. Further details it would be premature here to consider will come before us in a subsequent chapter.

This system has not been sufficiently long before the bee-keeping world to have permitted of a practical test so thorough as its author has no doubt given it before he ventured to speak so positively in its favour; but, judged by the light of theory and old experience, as I have endeavoured now to do, it promises great things to those raisers of comb honey who will carefully follow it.

In a state of nature, the swarming instinct is an essential to the maintenance of bee-life. Under domestication this is no longer true; so that we may safely seek to eliminate the instinct, and so not only come to possess a non-swarming system, but a non-swarming bee. The method of operation is purely a question of queen-raising, which must next engage our attention.

CHAPTER VII.

THE RAISING AND INTRODUCTION OF QUEENS.

The Feeding of Larvæ—Royal Jelly a Misnomer—Normal and Emergency Queen-cells—Queens of Low and High Type: How Produced—Early Drones—Cell-placing in Nuclei—Determining the Position of Queen-cells—Alley's System—Cheshire Nucleus Hive—Dividing Frame—Queen Nursery for Hive—Lamp ditto—Management of Virgin Queens—Breeding to Points—The Question of Size Considered—Breeding out the Swarming Instinct—Selection of Drones—Artificial Fertilisation—Queen Introduction—Caging—Chloroforming—Direct Introduction.

In Vol. I., especially at pages 26, 82 *et seq.*, I have already devoted much attention to my discoveries of the methods adopted by the bees in rearing their queens, and it will now be most convenient to direct my readers to these passages, contenting myself with a passing reference to those points which are vital to the understanding of the exceedingly important question now before us. That two kinds of eggs only are deposited by the queen has long been known; and it would appear that the Greeks of

the Ionian Islands, in a remote antiquity, practised rudely the art of queen-raising, by adopting methods which induced the bees to convert into queens some of those eggs which had been laid in worker-cells, and which would have, naturally, yielded workers only.

Bee larvæ, male and female, when they leave the egg, are not fed on a mixture of pollen, honey, and water, as is so constantly asserted—for they are then too small and tender to deal with pollen grains as a portion of their food—nor are they fed upon regurgitated material, as was taught by Dufour; but they receive from the nurse bees a secretion, which is truly a milk, from a gland carried in the head, and which, in the nurses, is extremely active (No. 1, Fig. 16, Vol. I.) Those larvæ intended for workers or drones undergo weaning, the former being the more quickly deprived of the highly nitrogenous food just referred to, and for which is then substituted pollen, honey, and water—the pollen containing non-digestible and waste matters, which collect in the blind bowel, and subsequently stain the comb of a dark colour. The queen-expectant is practically not weaned, but is fed on with copious supplies of secretion diet, added without stint by the workers crowding on her cell, and ever inserting their heads, in order that they may add their little quota of nutrition to the lucky baby. This nutrition collects far above the immediate needs of the insect; although, probably, the great amount in which it is given is necessary to retain moisture and permit of endosmose (feeding by absorption) long after the cell is sealed. The so-called "royal jelly," then, is given to all bees alike at their birth. It is

soon cut off from the workers, and continued to the end of the chapter with the queen, while the drones receive a medium quantity.

Reasoning from these premises, it would appear that the secretion diet has some curious power of developing and strengthening the reproductive faculty, which, in the worker, remains in abeyance, although it is not absolutely absent. At the same time, we have brought before us two points—viz., first, the raising of drone-brood is far more expensive and exhausting to a colony than the raising of an equal breadth of workers; and, second, that queen-feeding is not only exhausting, but not fully within the reach of little and weak lots, which are, consequently, unable to produce queens of the highest quality, of which we shall have further evidence if we examine the young worker larvæ in colonies in dissimilar conditions, when we shall note a vast difference in the amount of food given to the babies. In swarms, *e.g.*, the first hatched are fed so profusely that they look almost like the inmates of queen-cells, because the workers are far in excess of the nursing that is to be done by them; while in poor colonies, with a considerable breadth of brood, or in those that have been over-swarmed, the larvæ appear dry and foodless, because their little throats carry down more than the nurses are easily able to prepare.

As, from the foregoing, bees are able, by feeding, to convert any young worker larva, or egg which might produce such, into a queen, the bee-keeper has but to remove the mother from a stock, and supply, if needful, the eggs or young larvæ, and the bees will do the rest. When they discover their queen-

lessness, a mournful search is commenced. The alighting-board and hive front are never free of workers running to the right and to the left, and investigating every corner. The usual wise division of labour is replaced by a ludicrous waste of power, since every bee seems to think it necessary that she should personally scrutinise the spots that have been visited a thousand times before. The trained eye, giving a glance at the alighting-board, knows at once that the queen is missed.

When hope has faded away, and the search is pronounced useless, order again reigns, and the bees settle down to queen-cell building; but those who think that cells constructed under these circumstances are like those which are produced to supply successors to the old mother who is destined to leave with a swarm, are in error. In the latter case, cups in convenient positions, either on the edge of the comb, or on its side, are based upon a solid foundation of dense wax, aided by comb-nibblings and scraps in general, so that it is nearly of the colour of the comb upon which it begins to grow, and in this cup (*nqc*, Fig. 77) the queen deposits her egg, which is from the beginning destined to form a queen. In the illustration—drawn from an actual cell, divided by a knife dipped into alcohol—it is worthy of remark that honey (H, H) filled the parts of worker-cells upon which the queen-cup was fixed, and that the cells below (*rc*) were cut back, so that full accommodation should be given to the royal cradle and its crowd of attendants.

When queen-cells are built in the absence of a

queen, it is clear that either an egg or larva must undergo removal, or that the base of the cell upon which the egg is placed, and to which it is fixed, must have existed before the queen's departure. Although I noticed, several years ago, in one or two cases, circumstances which seemed to conclusively indicate the removal of eggs, and have seen a queen-cell built quite apart from any comb, with its base

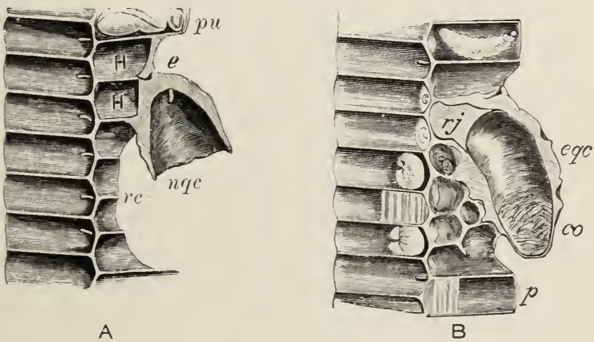


FIG. 77.—THE TWO VARIETIES OF QUEEN-CELL IN SECTION (Natural Size).

A, Position of Comb from Hive under swarming impulse— *nqc*, Normal Queen-cell; *e*, Egg; *rc*, Reduced Worker-cells; *pu*, Pupa; H, H, Honey. B, Position of Comb from Hive which has lost its Queen—*eqc*, Emergency Queen-cell; *rj*, Royal Jelly; *co*, Cocoon; *p*, Pollen.

upon the bottom rail of a frame, as though a dropped egg had been utilised, I am still doubtful, and only feel it safe to say that, practically, eggs must hatch, and the larvæ must be brought up where the former were laid. Under these circumstances, the worker-cell is, of necessity, transformed into a queen-cell. To this end, three surrounding cells are obliterated, in order to supply foundation-room for the heavy

waxen* supports the pendulous extension will need, while many worker-cells beneath (B, Fig. 77) are cut back, and, for the time, rendered useless by pittings and cross-webbings, to give the new structure firm fixings. Such cells have been accurately called emergency queen-cells (*eqc*), and are produced by bees, without external interference, when they determine to supersede their queen on account of growing infirmity. From this it would appear that the queen is a party to the project of leaving with a swarm, although she is not invited to take steps for her own deposition—she, in the former case, laying, at the suggestion of her children, what may be conveniently called a queen-egg; while, in the latter, they transform into a queen what she intended to be a worker.

It is now of importance to determine whether the queen produced under the swarming impulse (the queen-egg queen) is superior to the queen produced under conditions of emergency; and here I can only refer to the anatomical demonstration which I have had both the honour and good fortune to be the first to make, and which, as given in Vol. I, conclusively proves the mode in which the egg receives its fertilisation—an unvarying process indicating that the egg in the queen-cup differs in no particular from that in the worker-cell. Admitting, then, that eggs in queen-cups are not superior to those in worker-cells, it is still possible for the queen from the emergency cell to be greatly inferior.

* Rarely, queen-cells are made extremely thin, and Mr. Neighbour kindly gave me one, not more in any part than $\frac{1}{150}$in. in thickness. Thin webbing to the surrounding comb held it in place.

The serious disadvantage of queenlessness we have already noticed; and when bees discover this to be their condition, in hot haste to replace the lost one, they may (and all the races, save, perhaps, Cyprians, frequently do) select larvæ which have already passed the age of weaning, and are, consequently, beyond that fork in the road of development which divides the path of queens from that of workers. The distinctive organs of the latter are therefore already in progress, and, although a new turn is taken, and a queen is, in the end, produced, she is not of the highest type; and those so formed, while having less than the normal number of ovarian (egg-bearing) tubes, I have found to possess well-marked indications of the gland No. 1, which is especially the property of the worker, for she alone has to feed brood; but all perfect queens, started from the egg, are as truly devoid of this gland as is the drone himself (Vol. I., page 81). The fact that queens are started from the egg in normal queen-cells is suggestive; but, in addition, it is noticeable that the amount of food given in the queen-cup exceeds that supplied to a worker, even at the initial steps, so that the argument in favour of securing queens which received their promotion directly after leaving the egg, needs no enforcement. Worker larvæ between two and three days old are capable of being converted into respectable-*looking* queens; but Mr. Doolittle is stated by Professor Cook to have known queens to be reared from worker larvæ taken at four and a half days after hatching. In this case, the cells adjacent to the one containing the selected

larva were removed in the usual manner, and the larva surrounded by a royal cell. Mr. Doolittle is an observer who deserves respect, but my experience has not furnished me with any exactly parallel instance. Such a queen would be an interesting subject for dissection, for I should expect her to be neither worker nor queen, but a little of both. Returning to our point. Should the bees of a deprived stock but start one queen from an advanced larva, she, because she first hatches, will alone survive if no queen-cells are removed, and so the practice of securing a new queen by the simple displacement of the old one is, although very convenient, not the very best (see page 265), and would, probably, if persisted in for many generations, deteriorate considerably the strain of bees subjected to its influence.

We have now before us the general principles by which to be guided in raising queens of the highest excellence, and in the forefront stand these two: First, the larvæ should be intended by the nurses for a queen from the very beginning; and, second, the nurses must be numerous, and well nourished, and not have put upon their secretive powers a drain which they cannot fully bear. The conditions under which normal queens are produced at the epoch of natural swarming especially emphasise this second point. Food is then so abundant, that the old mother is beginning to be crowded in her brood-nest; and as a consequence, while young bees are daily more numerous, the amount of nurse-work demanded is rather declining. Under these circumstances, the heavy but then easily-sustained burden of queen-raising is naturally under-

taken. It is the great defect of ordinary artificial swarming, that the swarm is first removed, and then the weakened colony has not only to tend its brood, but also to raise its queen. Under normal conditions, to which exceptions are very rare, the queens are fully fed first, and then the swarm departs. All this can be imitated very completely by following the natural sequence of raising our queens in order that swarms may be made, rather than making swarms in order that queens may be produced; hence was given the caution at page 265.

With our present slight control over fertilisation, it is highly desirable that we obtain in number abnormally early drones from the stock which we have selected to supply the male element. This should be strengthened by brood from other colonies, and stimulated by carefully-sustained feeding. As the bees begin to crowd, a comb of drone-cells should be placed in the centre of the brood-nest, care being taken at the same time that the bees should have no combs they do not fully cover. Very soon, drone-eggs will be laid; and now, in our fitful climate, watchfulness is needed, for a few cold nights, accompanied by uncertain income (for the bees are not encouraged appreciably by heavily-stored combs), may cause the objects of our hope to disappear, in furnishing a repast to the workers.*

The stock from which eggs for furnishing queens are to be taken should have been kept carefully going, and, about the time the earliest of the drones

* Drone-eggs are safe if given, so soon as laid, to a queenless colony; but this involves more labour than simple attention to feeding.

commence to hatch, a frame of fresh, bright comb or foundation should be placed in the centre of its brood-nest. In three or four days, this will be well furnished with eggs; but, in any case, we must wait until the earliest-laid begin to hatch, the tiniest specks of food at the bottom of the cells being then alone discoverable. We now remove the frame to the hive in which the queen-cells are to be built out. We shall get the latter more conveniently arranged along the edge of the comb if we practically divide it, by placing a horizontal bar across the centre of the frame, and provide the upper and lower parts with foundation, so that about an inch space is left between each piece and the rail beneath. This cross-rail should be $1\frac{1}{8}$in. nearly in width, to prevent the combs opposite to it being unduly built out. Some recommend cutting one or two holes, perhaps 1in. long and 4in. wide, in the comb itself with the aforesaid object.

We now remove the queen, and all eggs and uncapped brood, from some strong colony, preferably leaving all the bees, and using the queen to displace some old or undesirable one, and distributing the brood amongst other stocks, where it will be of most advantage. If the queen must be retained, a nucleus can be formed by giving one or two combs of brood and one or two of store. Inserting the comb of selected eggs, and carefully feeding the stock if need be, secures, it will be seen, all the coveted conditions, and the queenless colony will immediately start royal cells, in numbers varying with its strength and race—Cyprians and Syrians sometimes commencing four or five

dozen. It may be here remarked, in a parenthesis, that Dr. Tinker objects somewhat to the plan detailed, on the ground that the bees recognise that the brood is not their own, and refuse to feed the royal foster larvæ as they should. This idea is quite contrary to general experience, but Dr. Tinker favours a plan which may often be advantageously adopted. He says: "To rear fine queens out of season, and at an unfavourable time, take from a colony its queen. In

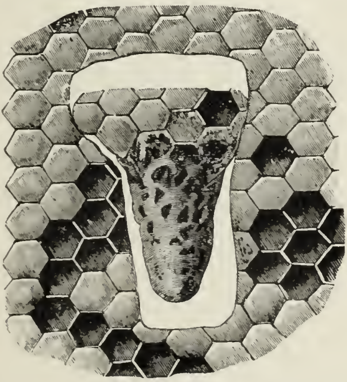


FIG. 78.—INSERTED QUEEN-CELL (Natural Size).

three days thereafter, take out the larvæ from the formed queen-cells, and introduce into their places small larvæ (as they lie in the worker-cells not larger than $\frac{1}{16}$in. across) from the best breeding stock. The bees fail to recognise the change made, and as the larvæ get a big start in the royal food in the cells, they make the largest queens it is possible to produce." Alas! then it is not only in the human family that the rightful heir gets sometimes dispossessed by a substituted baby. But to return.

When the cells have been sealed five or six days, preparation must be made for placing them, and the formation of nuclei will usually be the most desirable. The common method is as follows: A comb of hatching brood, with the adherent bees, but without the queen, is taken from a sufficiently populous stock, placed in a hive, with a comb of store on each side of it, sufficient bees being added, by shaking or brushing, to keep all in condition, and a dummy or dummies being added to close up the space. Twenty-four hours later, the queenless lot will gladly receive the royal cell, which should be ripe (see page 255), and which it is commonly recommended to cut from its position with a portion of comb. Having previously prepared an opening—using a very thin and narrow-bladed knife—amongst the brood of the central comb of the nucleus, the queen-cell may be dovetailed in, to be fixed by the bees, as in Fig. 78, allowing sufficient space for the escape of the hatching queen. This plan gives much trouble, greatly damages the combs, which are never again neatly repaired, and, by the time it requires for its performance, is likely to expose the cells to chill. The cell, at the time of its removal, is soon to hatch, and I find it quite sufficient, and fully as safe, even in chilly weather, to detach with it a small piece of wax tracery, which, when the cell is passed between the top bars (*tb*, *tb*, Fig. 79), is pressed over (*f*), and flattened by the finger. The attachment the bees cannot gnaw away, because it is covered from them by the quilt. They nibble down their comb a little at *a* and *b*, and gather on the cell, which may be removed,

without a trace of injury to anything, when the queen has left it.

The bees will frequently huddle their queen-cells together in such a manner that it is impossible to separate all from one another without an occasional mishap, making a small opening somewhere, when the bees will almost always refuse to let the cell hatch, although we may repair with a little wax, as some writers suggest. My handiwork, I believe,

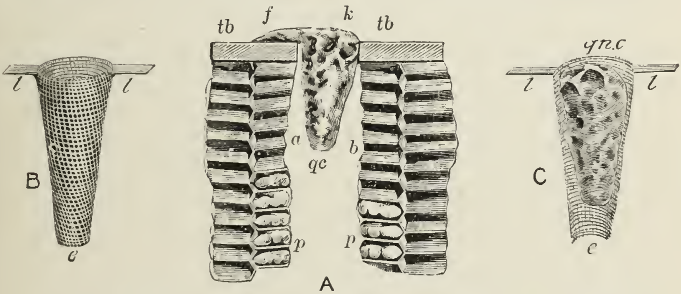


FIG. 79.—QUEEN-CELL INSERTED BETWEEN FRAMES AND COMBS (Scale, ½), AND DOOLITTLE CAGE.

A—*tb*, *tb*, Top Bars; *qc*, Queen-cell; *p*, *p*, Pupæ. B, Doolittle Cage—*l*, *l*, Lugs; *e*, Exit. C, Doolittle Cage in Section—*qnc*, Queen-cell; other Letterings as before.

has never been accepted where I have allowed the little fidgets an opportunity of pulling it to pieces. If we can break down our clusters to two, we can generally save all, for a pair passed between the top bars, if carefully watched, may be removed, before mischief has happened, after one queen has left. The remaining cell will be given to a nucleus, which, even if kept waiting, will only amuse itself by building cells that are soon to be destroyed. A caution is needed with reference to separating the top bars, with a queen-cell between them.

They are often attached firmly to the latter, which may be torn and spoiled unless a thin knife be run down at *k* in the Figure.

How much it would tend to our convenience if the bees could be taught to build their royal cells in a symmetrical arrangement, at regular intervals! and many devices have been stated to possess the virtue of giving the necessary instruction, but my experience with them leads me to think that most of their advocates have not seriously tried them. Merely enlarging the cell mouth with a piece of conical wood I have not found to determine the position of a queen-cell one time in twenty; but breaking down the cell walls on the under side, after the larva has escaped from the egg, and continuing the destruction for ½in., or till the bottom edge of the comb is reached, is more, though by no means uniformly, successful. It is bad economy, however, to allow the queen-raising stock to build more queen-cells than we can utilise, or any in such positions that they must be useless. If an examination be made, the excess, or the awkwardly-placed ones, may be destroyed by a gash, fatally injuring the grub.

Mr. Alley,* a very prominent American queen-raiser, has carried the problem of placing royal cells to a greater degree of refinement than any other; and, without recommending—for I venture on several points to differ—I give an outline of his system, which, to me, was too troublesome to be continued, although so interesting that its omission would be

* "The Bee-keeper's Handy Book," by Henry Alley.

a grave mistake. Mr. Alley does not keep his queen-mothers in full colonies, but in miniature hives, the five frames of which give a total comb-space not exceeding one-and-a-half British standards. His object is to minimise the risk of injury to a selected and valuable mother, and to quickly secure batches of eggs of a known age; but, admitting these advantages, I think it a somewhat doubtful policy, for, judging by numerous well-known analogies, if the queen be not in the fullest activity (and, notwithstanding the frequent exchange of the middle comb for an empty one, she cannot be in this sized hive), her eggs are less likely to yield highly prolific queens. Special moods and passing conditions in a fruitful animal are often continued in its offspring by heredity; and, referring again to natural swarming, we find the normal queen-cell (*nqc*, Fig. 77) to be furnished at the very time the assimilative and constructive functions of the queen are under the fullest stimulation.

Placing a frame of drawn foundation or young comb in the centre of the hive, it will be found filled with eggs in twenty-four hours, and is, in due course, transferred to the queen-raisers. These are prepared by Mr. Alley in a special manner, in conformity with his views as to the origin and nature of "royal jelly," with which it will be seen, from what has already appeared, I am in only very partial agreement. Manipulating in a room, so as to escape the hindrance of wet or cool weather, he deprives a strong colony of queen, brood, and combs, using smoke to induce the bees to gorge, and to keep

them in check. They are brushed into a bottomless box, somewhat smaller than a standard hive, and covered with wire-cloth above and below. So soon as they miss their queen they start an uproar, which knows no pause until they are released (see page 263). Their confinement is continued in a cool, dark room, for ten or twelve hours, a pint of syrup being given them. Reasoning from what Mr. Alley has

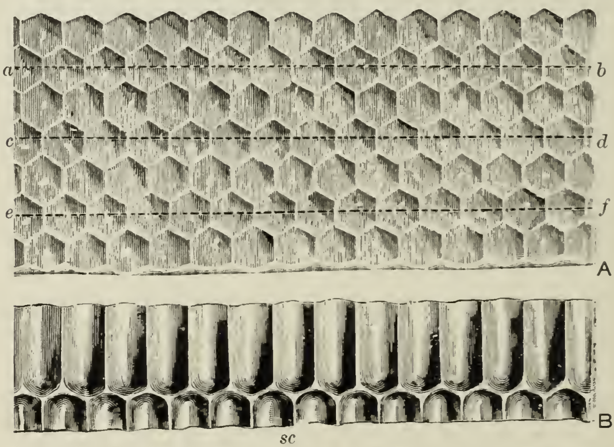


FIG. 80.—ALLEY'S SYSTEM OF PREPARING COMB FOR QUEEN-RAISING.
A, Comb from Alley's Miniature Hive cut into Strips (Natural Size). B, Side View of One of the Strips—*sc*, Shortened Cells.

observed in pigeons, he concludes, quite erroneously, as I think, that confined queenless bees "prepare or secrete the white, milky food which we find in the bottom of the cells around the eggs (subsequently) given them for rearing queens, and which is of the same nature as the royal jelly upon which the young queens feed while confined to the cell; also, that it is necessary that they be kept queenless until instinct

impels them to make this important preparation for cell-building."

Everything being now in readiness, we visit the hive in which the breeding queen is kept, and take from it the middle comb placed there four days previously. We find in the bottom of the cells a white, almost invisible, transparent larva, just hatched, and already floating in a tiny quantity of food. Taking this comb to the bee-room, which has been warmed to prevent the larvæ from being chilled, we cut through each alternate line of cells (see dotted lines *ab*, *cd*, *ef*, Fig. 80), so as to divide the comb into strips. These are turned on to their sides (B, Fig. 80), on a flat table, and the cells on one face (*sc*) cut down by a thin, keen knife, to within ¼in. of the midrib; and then each alternate egg in these reduced cells is destroyed, Mr. Alley recommending for this work the dipped end of a common match. It is inserted to the bottom, twisted between the thumb and finger, and the object is accomplished. Sufficient room is thus given for large cells to be built, and for the bees to work around them, while it permits of their being afterwards separated without injury. The strips have yet to be fixed in position. Mr. Alley proceeds thus: He has previously cut from a broodless comb—a number of which he keeps in stock, and devotes to the purpose now explained—such a portion as will give room to the strip A, B, Fig. 81, and the queen-cells to be built. The line of section is made convex beneath (see Figure), so that the cells should diverge as they descend. A mixture of two parts rosin and one beeswax is heated care-

fully, and the uncut cells of the strip B, Fig. 80, are dipped into it. It is immediately placed in position, cell mouths downwards, and pressed with the fingers gently into place, care being taken not to crush or injure the cells in so doing. When the latter are completed, the strip is taken with them, and the comb thus left free for similar use subsequently.

The "nucleus," or queen-cell hive receives the

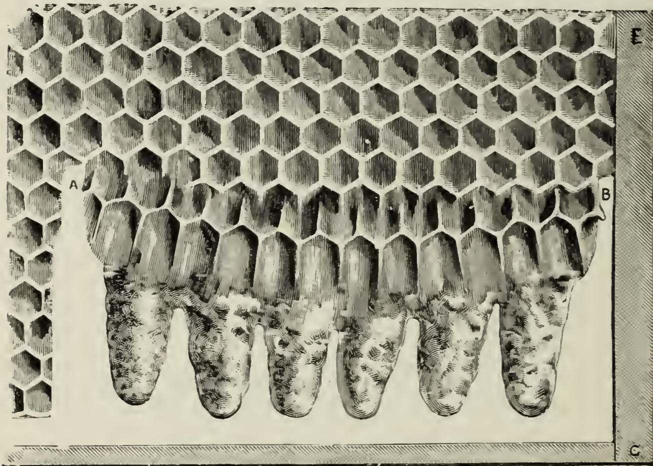


FIG. 81.—QUEEN-CELLS BUILT UPON ALLEY'S PLAN (Natural Size).

frames and cell-building strips, and such combs as may be required to fill it. It is placed on the stand whence the bees (page 298) were taken, and at such an elevation that the bottom edge of the alighting-board meets the top edge of the box containing the worried and impatient prisoners, for whose escape a slight gap is made, so that any objectionable drones may be strained out. If none exist, a free regress is

permitted. No worker-brood is given to these bees, of course, as all their energies are to be concentrated on queen-production; but a little capped drone-brood will greatly encourage them. If the imprisonment begin in the morning, the liberation may be made at night, when the bees, by the next day, will be reconciled to the new state of things, and have their cells already started. That these are approximately perpendicular and mouth downwards will puzzle none who will look at the form of the normal cell (A, Fig. 77). The cells will grow downwards, and occupy the position shown in the Figure, in which Mr. Alley's has been partially followed. In practice, however, the spaces between the cells will be, to a considerable extent, filled with a wax septem, deeply pitted, and sometimes stored with honey; but these additions will not prevent the knife from effecting the separation of the cells when they are ready for transferring to nuclei. Mr. Alley, for a reason which I have previously explained, cautions all queen-breeders against permitting the bees to build too many cells. He considers twelve sufficient for an average colony of all races but Cyprians and Syrians, to which a larger number may be permitted. The excess may be destroyed by the match, as before. My experience shows that, by this plan, the bees will not convert every egg or larva given them into a queen; and often many are missed, so that more strips must be supplied than would, if fully utilised, make up the number of cells we desire to have constructed. Liberal feeding, as previously hinted, if the honey-flow be not abundant, is an actual necessity.

We return to the question of nuclei, for which the majority of bee-keepers use ordinary hives reduced by division-boards, as before explained. It has been a practice with myself to associate the nucleus with the stock on one stand—as I

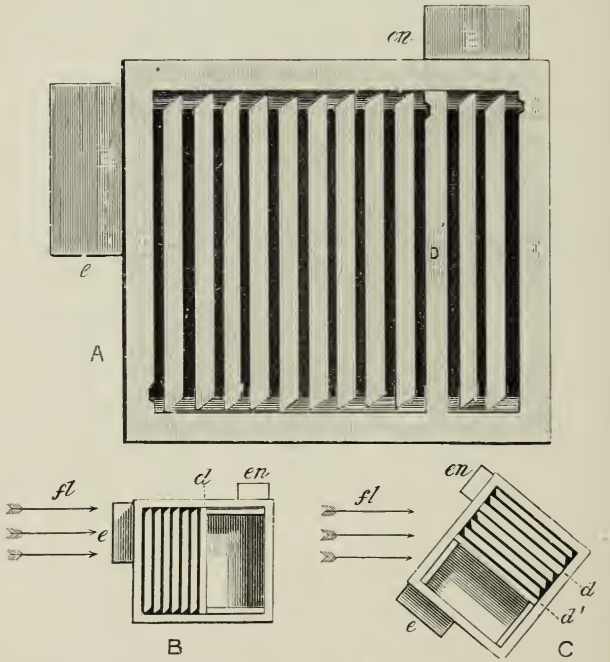


FIG. 82.—CHESHIRE ARRANGEMENT OF NUCLEI (Scale, $\frac{1}{10}$ and $\frac{1}{30}$).

A, Stock and Nucleus—*e*, Entrance to Stock; *en*, Entrance to Nucleus; D, Division-board or Dummy. B, Small Colony in Hive—*d*, Division-board; *fl*, Flight Line of Bees. C, Same Colony divided into two Nuclei. Other Letterings as before.

believe, with increased economy and convenience. The stock has its entrance at one corner (*e*, A, Fig. 82), the most suitable spot for many reasons, and the best by far for "Wintering" (which see). When

it is desired to establish a nucleus, for the purpose of getting a young queen into laying condition, two frames of the stock hive, one containing brood and adherent bees, are placed behind the division-board (D). The warmth from the parent aids the nucleus, so that two frames are amply sufficient. The hive is now rotated about 45deg. from its former position (B) to that of C, by which many of the bees in flight will enter the nucleus chamber, whose mouth has been turned towards the old line of flight, while the mouth before used by the colony has been turned from it. In twenty-four hours, a queen-cell may safely be given to the nucleus, and the queen hatching therefrom allowed to remain until she begins to lay, when she or the queen of the parent colony may be utilised elsewhere, and the two lots of bees united, without any loss or disturbance of the apiary whatever, by simply removing the division-board, and alternating the frames of stock and nucleus, the mouth of which is now closed while the hive is turned into its former position (B). Should the stock, when the operation is undertaken, be not yet full, the combs or combs and bees, as most convenient, may come from any other colony, and the union, at the proper time, be effected as before; and should the colony on the stock be weak, only occupying five or six frames, it may be made into two nuclei by the same process, with the addition of a second division-board (*d′*, C), arranged like that of the Cheshire Makeshift (Fig. 16), so that both nuclei are at the back of the hive, assisting each other in maintaining temperature.

Objections are quite rightly made to the intro-

duction of a second sized frame, even for the raising of queens; but my dividing standard is not really a new size, since it is at all times admissible in the standard hive, taking its place as one of the ordinary frames. I have improved upon the pattern given in my "Practical Bee-keeping," by making the frame at once easier of construction, stronger, and more simple. The Figure needs but little explanation. The proximate side bars (*sb*, *sb*, A, Fig. 83) of the halves are wider than the rest of the frame, since when the

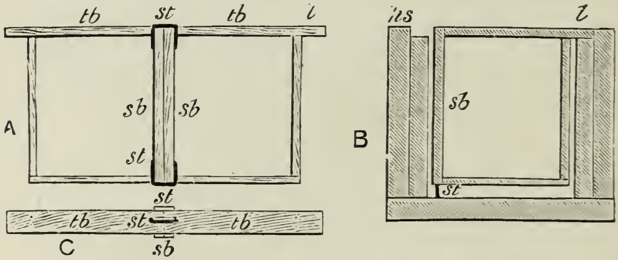


FIG. 83.—CHESHIRE DIVIDING STANDARD FRAME (Scale, $\frac{1}{10}$).

A, Frame as used in Standard Hive—*l*, Lug; *st*, *st*, Wire Staples; *sb*, *sb*, Side Bars; *tb*, *tb*, Top Bars. B, Hive in Cross Section, with Half-dividing Frame within it—*hs*, Hive Side. C, View from above Top Bars. Lettering as before.

latter stands with non-dividing ones in the hive, if the centrally-placed bars were only of the usual $\frac{7}{8}$in., the comb opposite to them, wherever honey is stored, would be built out until a single bee-space alone remained, whereas opposite the brood a double bee-space would be left. The troubling irregularity is in this way entirely avoided. The two halves are held together by stoutish wire staples (*st*, *st*, A and C), pushed into holes made to receive them, so that they grip the side bars together. The frame is filled by natural building, foundation or, if needed quickly, by

a comb from a "standard" transferred to it. Being furnished with brood and store, it is, when required, lifted from the hive, and the staples withdrawn and replaced in previously-made holes in the end grain of the side bars, forming in each half a sort of foot (*st*, B), which, with the one ear, holds the half frame in position. The two halves are placed side by side in a small hive, 3in. full in width, 9in. deep, 7½in. from front to rear, and between the two combs the queen-cell may be fixed next day, as at A, Fig. 79. I make the mouth of these queen-raising hives large—about 1¼in. square—to give added bees a rapid entrance, but have before this mouth a sliding door, which contracts the opening if necessary, until one bee only can pass.

If the dividing frame be given a wide space in the stock hive for a few minutes before removal, sufficient bees are usually taken with it to supply the nucleus; if more are required, they may be shaken down in front in the well-known manner. Of course, care is requisite that the queen of the stock be left at home. It is possible to secure the fecundation of several queens in succession in each of these little hives during the summer; but their combs need to be once or twice exchanged for another dividing frame carrying hatching brood. If the nucleus walls are thick, and they are well covered above, so that the bees are neither chilled at night nor scorched by day, the two little combs are perfectly sufficient. Several of these nuclei may stand near to each other, facing the different points of the compass, and, when queen-raising is over, all the combs may be gathered into

one hive to receive such help as will put it into condition before autumn brings work to an end. The objection that bees in such small numbers swarm out is only true when they are ill cared for. Feeding with candy cake constantly, seems to cure the evil. With this attention, and leaving each laying queen until she has filled the combs where free of store, these small nuclei will sustain themselves, in average seasons, with a drain upon the larger stocks that is almost inappreciable.

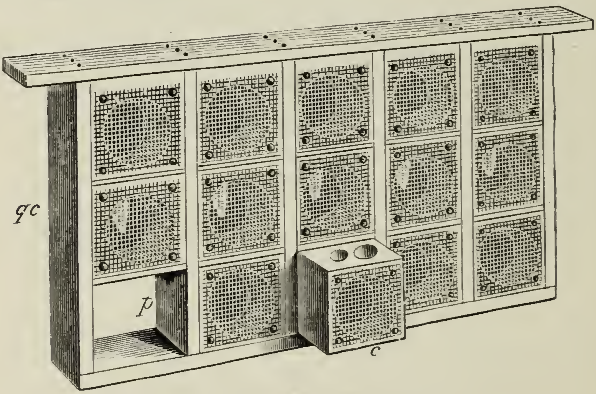


FIG. 84.—QUEEN NURSERY (Scale, $\frac{1}{5}$).
p, Partition; *c*, Cage drawn from Position; *qc*, Queen-cell.

It sometimes happens that a second batch of queen-cells are ready, and demanding immediate attention, if they are not to be destroyed, and yet no nucleus hives are at liberty to receive them. Possibly, bad weather has delayed the first lot of queens in securing impregnation, and they must now remain where they are until eggs are laid, or until they are discarded as useless. To meet this difficulty, a device called a queen nursery has been intro-

duced. Mr. Alley's arrangement is practically as follows: A frame (Fig. 84), say, 1in. wide, fitting the hive in use, is divided by partitions* (*p*) into a number of small spaces about 2½in. square, and into these are fitted cages (*c*), consisting of a wooden block, covered on both sides by wire cloth, and having two holes above, into one of which the queen-cell is inserted, while the other receives a sponge dipped in honey, to supply the queen with food. Mr. Jones makes a nursery in which the queen-cell is held clipped by an india-rubber band, and gives a little trough of food beneath, adding a few bees as attendants; but the principle is the same.

The frame being placed in the centre of a strong stock, with the queen-cells fixed in position, the latter, in due course, hatch; but, strange as it may appear, a normal colony will certainly allow the queens to starve, while even a queenless one will generally refuse to feed them. They are, therefore, dependent upon the added food, in the form of honey, or honey and sugar; and although the queens, under these conditions, will continue to subsist even for weeks, they undoubtedly suffer from a most prejudicial defect in their diet. Queens, between hatching and mating, are normally great consumers of pollen (page 84, Vol. I); and this is required, as furnishing nitrogenous material, to add to the volume of their tissues. Queens allowed access to sugars only, become attenuated, although not visibly reduced—for the hard, chitinous envelope prevents external shrinkage—and the bowel contains, instead of abundant

* Mr. Alley uses no partitions—a source of much inconvenience.

pollen residues, a dirty-coloured, nearly fluid, mass. Against ordinary nurseries, with all their convenience, we must regard this objection as a grave one, which is entirely avoided by placing, side by side, over natural stores of pollen and honey, my flat introducing-cages (Fig. 89), or any similar forms ; but unless wooden strips be added at the edges, to delay the bees in burrowing, the royal cells, or queens, would not be safe for more than three days.

About twelve years since, while endeavouring to follow out the changes through which the larva became at length the (imago) perfect bee, I found that, if the former be kept in a warm and damp atmosphere, removal from the cell was by no means quickly fatal, and that queens so treated could be carried through all their changes while exposed to observation ; and, moreover, that fluctuations in temperature considerably delaying their development, did not prevent their arriving at length at the perfect stage, although they were miserably enfeebled. All know well that, in warm weather, workers will gnaw out, here and there, from comb that has been days away from its natural protectors. Reasoning upon this observation, an American, Mr. F. R. Shaw, constructed what is now known as a lamp nursery, the object of which was to carry queen-cells on from sealing to hatching, apart from the interference of the bees. Mr. A. I. Root improved upon Mr. Shaw's plan, substituting water for hot air,* but defects remained, which I have endeavoured to reduce, making the nursery as at Fig. 85.

* "A B C of Bee Culture"—"Lamp Nursery."

The main part of the apparatus is really a hive, with double walls of zinc or tin plate (the former is far the more durable, and is not open to any valid objection, if varnished within with shellac, dissolved in spirits of wine), the space between which, about an inch, may be filled with water (W, W), to entirely sur-

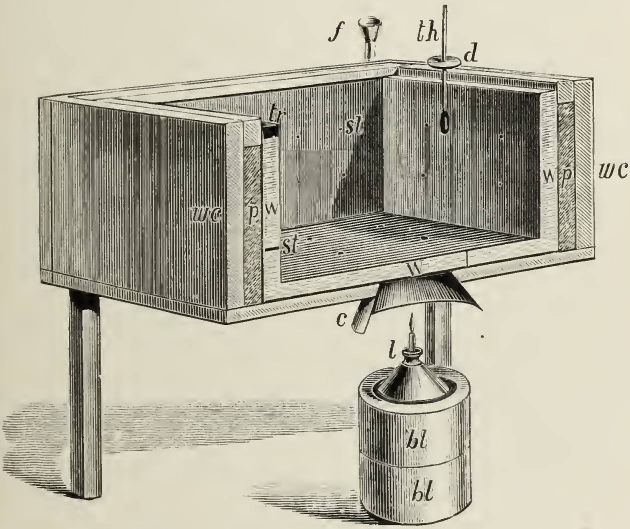


FIG. 85.—LAMP NURSERY IN SECTION—Author's Arrangement (Scale, $\frac{1}{10}$).

W, W, W, Water in Zinc or Tin-plate Double Cistern : *p*, *p*, Packing to Retain Heat ; *tr*, Open Water-trough ; *st*, *st*, Staples ; *wc*, Wooden Case ; *f*, Funnel ; *th*, Thermometer ; *c*, Cone of Metal ; *l*, Lamp ; *bl*, *bl*, Raising-blocks.

round the contents of the nursery, except on the top. To assist in the filling, a pipe, surmounted by a small funnel (*f*), is passed through the outer case (*wc*), and enters the water cistern at the top. On the opposite side another and smaller pipe is provided, to allow the contained air to escape. The weight of water

would cause the metal to bulge badly, unless several staples (*st*, *st*,) were soldered into the sides. While the cistern is under construction, a piece of plank, 1in. thick, is passed between the inner and outer skins, two holes are bored opposite to each other, and a bell-wire passed through and fastened, by solder, as indicated. An outer casing of wood is most desirable, and this should permit of packing (*p*) with cork-dust, charcoal-dust, or sawdust, so as to prevent, to the uttermost, needless leak of heat. The case has a hole beneath, 5in. or 6in. in diameter, exposing the cistern, and here a truncated cone of metal is soldered to husband the heat of the lamp. Legs are added to bring it to a convenient height, and to permit of variations in the height of the lamp (*l*), which stands on blocks (*bl*, *bl*).

The water required for a nursery capable of receiving ten standard frames, would be about three gallons, or 30lb.; and so great is the specific heat of water, that this amount, protected as described, and warmly covered above by quilting, would cool with extreme slowness in the absence of the lamp, while its temperature would be equally long in rising if the lamp power were in excess of that required. Gas may be used; but if a lamp be employed, it should be of small size,* its reservoir yet being large enough to hold a thirty hours' supply. To start, fill with hot water, cover carefully, and adjust your thermometer (*th*), either placing it inside, or passing it through a hole in the cover, retaining, by a fixed circular disc (*d*), only sufficient of the

* I find my nursery is amply heated, even in cold weather, by the smallest round-wicked paraffin lamp obtainable.

stem above the quilting to permit of reading it without disturbing anything within. Now let the temperature drop till 90deg. are reached; light your lamp, and regulate its flame and distance until the thermometer stands steadily. If we do no more than this, the air within the nursery will be extremely dry, and, consequently, injurious to queen-cells, for, under normal conditions, the water carried into the hive in limpid nectar, or as actual water, keeps its air almost at the point of saturation. To remedy this, I depress one side of the cistern into a long trough (*tr*), and this I keep filled with water.

No honey now so stiffens that it is unfit for the queens, as Mr. Root complains, and food given to them will remain in condition for days. Our queen-cells may now be cut out, and placed free within the nursery, to hatch in the open; or they may be placed in large wooden pill-boxes, having two or three holes to admit air, and a little piece of stored comb, to feed the new-born aspirants to maternal honours, which will do perfectly well, without further attention, for a few hours after making their exit from the cell. If we object to cutting the comb in order to remove the cells, the frames, freed of all bees, may be suspended within the nursery; but unless these combs have been rapidly filled with eggs, by being placed empty in the centre of the queen-raising stock, as before explained, two difficulties meet us: first, all the brood cells will not be sealed, and so some of the larvæ must perish; and next, some of the workers will hatch out before the queens, and so cause much confusion and trouble. As, however, workers hatch on the twenty-first day from

the laying of the egg, and the queen nearly always on the sixteenth, if the eggs have been laid nearly at the same date, the whole of the worker larvæ and the queens will be sealed so nearly together that we can wait with advantage till the work of sealing is complete, so that no sacrifice be made ; and, next, all the queens will be out, and our comb returned to the hive some days before any worker hatches. The delay in the removal also reduces considerably the risk to the immature queens involved in shaking and brushing the comb so as to clear it of bees.

The bees losing their comb by its transference to the nursery, should not be left, even for an hour, broodless and queenless; so either give them a queen from the nursery, or another comb of eggs, to restart them queen-raising.

The destruction of immature queens by their hatched sister, aided by the bees, has already been noticed (pages 155 and 161), and the same instinct shows itself, although in diminished force, when the queen is alone, and in the unnatural conditions of the lamp nursery, to which, in consequence, frequent visits are needed, unless, occasionally, cells are to be torn open, or queens killed by the poisoned dart of a rival. The movements of a queen within a cell, beginning some twelve hours or more before she quits it, are easily traceable by holding the cell up to the light or to the ear. In the latter case, the nibbling of the cocoon is most distinctly audible, and such advanced queens may be transferred at once to the stock to receive them. Pulling off the cell from the comb, so as to damage the latter as little as possible, may injure the base of the cell,

in which case, and, perhaps, in most cases, it is best to give it in a Doolittle cage (Fig. 79), consisting of a truncated cone of wire-cloth, into which the cell is dropped. It is now placed between the combs, when the two ears supplied to the cage suspend it from the top bars of the frames. The sides and base of the cell are thus safe from attack, and the queen gnaws out in the usual manner.

When the queens are already free in the nursery, they must be introduced to nuclei. Unimpregnated queens are less acceptable to colonies than are laying mothers, and their introduction is, under ordinary circumstances, more uncertain. Mr. Heddon gives his experience as follows:* "We go to our nursery and examine for hatched queens about five times per day, going as early and late as we are up, so as to make the interval during the night, between examinations, as short as possible. We have not, as yet, had a queen destroyed. When you find one or more hatched, place each in a wire-cloth cage, and carry her to one of your previously-formed nuclei. Smoke the guards, and, removing the stopper from the cage, place the open end at the entrance of the nucleus, and let her run in. Just as she passes in, send a light puff of smoke after her, and leave the hive with your empty cage. I think that the less you arouse the colony, the surer you are of success. I advise the use of no more smoke than to make sure of subduing the guards.

"There has been some discussion regarding the best age of the nucleus at the time the young queen

* "Success in Bee-culture," page 30.

is run in. Some consider such introducing safe only after the nuclei have their queen-cells capped, which will be from three to six days after they are formed; but I have always endeavoured to get a young queen in some time between twenty-four and forty-eight hours after formation. I have, in many instances, failed to have my queens on hand as soon as I intended, and have this season run queens into nuclei of all ages, from six hours to as many days, and I think not a single failure has beset our efforts. We have found about one in fifteen of our nuclei queenless; but as we seldom look after these matters previous to a week after introducing, and have in no case found queen-cells on the combs, I infer that these queens were accepted, but were lost on their mating trip, or otherwise, afterwards." This question of introducing virgins will come before us again presently; but we have yet to discuss one or two points in reference to the selection of our breeding stock.

I remember well one of the most, if not the most, scientific of British poultry-fanciers, remarking that he had long desired to establish a breed with a special type of feather. "Give me a bird," said he, "with but one feather such as I seek, and I shall not despair; but that bird has not yet been found me." The idea here involved is of general application to all animal and vegetable races. Any peculiarity, if of service, may, by natural processes, continued through long periods, become settled into a specific characteristic, or may be quickly intensified by careful breeding, man practically leaping to the goal of natural selection, and bridging over what ages upon ages could only have

accomplished; but the point now before us is: What are the peculiarities that we require in our bees? All are agreed as to the desirability of great fecundity; stamina and longevity; gentleness and adherence to the comb under manipulation; great honey-gathering capability; an indisposition to swarm; good wintering qualities; good comb-building; solid and impervious sealing to honey; and a compactly kept brood-nest. But there are other points, which are of relative rather than absolute importance, such as purity of race, colour, and markings, both of queen and workers; and, lastly, size. It is clear that some of the first are mutually dependent; *e.g.*, fecundity and honey-gathering capabilities are inseparably connected, and longevity and wintering qualities go, necessarily, hand in hand. The special characteristics of the races, as such, will be treated of hereafter, while the question of hybrids or pure stock, and that of colour, must be settled by individual circumstances and tastes; although the latter has a practical application, in that light-toned queens are far more easily seen than are those that are dark.

The last point (size) is one upon which great misapprehension abounds. The idea that it is desirable to increase the dimensions of our bees is all but universal, and, since I have ventured, more than once, to stand alone in condemning it, I must give my reasons for so doing. *Apis dorsata* has been hunted up, although it is known to be a useless savage, simply because it is big, and that by the very persons who claim that the smaller hive bees are the best, in that they give their vote generally to the yellow

varieties. Fortunately, it is in the very nature of things impracticable to "hybridise" our hive bees with *dorsata*, over which we may inscribe "*Requiescat in pace.*"

But it is still necessary to point out that the smaller the creature, the greater, relatively, are its powers, both for a mechanical and a physiological reason. First, other things being equal, as an animal is enlarged, its weight increases as the cube, and its strength as the square only, of the ratio of the lineal increase. Thus, if a man could be developed until his 6ft. stature became 18ft., his weight would be increased no less than twenty-seven times; while his muscles, because three times their former width and thickness, would have only nine times their former power. Such a man would be just able to stand; but if he were to stoop to pick up a pebble, he would be too weak to rise again to the erect posture. This aspect of the question is quite mechanical, and may be further illustrated thus: An ordinary lucifer match, supported horizontally at the ends, will bear about 7000 times its own weight suspended from its centre; but by enlarging it 240 times, it becomes a great baulk of timber, which would be broken by once its own weight similarly suspended. Here we have the reason why ants can build nests which, in relative size, utterly transcend anything bigger creatures can accomplish; why some insects can jump even a hundred times or more their own height, while the gazelle can, at a push, do twice, and man and the horse once theirs, leaving the elephant to disdain jumping, as unsuited to his ponderous dignity.

The physiological reason is equally striking. Creatures

grow by transfusion of material in their living bodies, and the more solidity their tissues have, the more slowly does this transfusion occur. Some flesh-flies, in the earlier part of their larval state, will increase in weight two or three hundred times in twenty-four hours—a rate of development absolutely forbidden, by physiological and chemical laws, to creatures of larger proportions; for, other things being equal, as the size increases the rate of development must decrease. The inconceivably minute monad, weighing a fraction of a billionth of a grain, by absorbing nutrition doubles its weight and divides every four minutes. If food abound, and the fluid surrounding the creature be free of enemies, and not circumscribed, it, in the course of three or four hours, may produce in its descendants an amount of living, moving material exceeding the weight of the largest elephant; while the latter animal, with its digestive and assimilative powers stimulated to the uttermost, could only, in the same time, add a few ounces to the weight of its body.

The economics of the question must not be overlooked. In gathering from clover, it has been shown that about $\frac{1}{350}$th grain is secured at each visit. Let us imagine that our bee is enlarged twice, by which its weight has grown eight-fold. As it flies, carrying its large body from clover-bloom to clover-bloom, an amount of wear and tear is involved which is eight times as great as that accompanying similar movements in the normal bee. This wear and tear is replaced by food —of course, proportionately augmented, and which has to be deducted from the $\frac{1}{350}$th grain secured. The net increase to the stock is, therefore, less at each visit, in

the case of the large bee, than in that of the normal one. The former, however, has the advantage of being able to decrease its return visits to the hive to unload, because its honey-sac is larger; but this is the only gain, and it is much more than counter-balanced by the fact that, with normal bees, eight independent gatherers would be at work simultaneously for only the same wear and tear that would permit of the efforts of one if the bulk were increased as supposed. Selection has gone on for ages regulating the proportions of the wondrous insect between those extremes in which the loss by excessively frequent returns to the colony, and the loss through excessive bodily weight, balance each other, and has thus given us a bee whose size yields the best possible results.

The botanical reason for desiring no alteration was expounded in Vol. I. Flowers and bees have been constantly interacting. The build of every floret is adapted to that of its fertiliser, and, could we suddenly increase the dimensions of our hive bees, we should throw them out of harmony with the floral world around them, decrease their utility, by reducing the number of plants they could fertilise, and diminish equally their value as honey-gatherers. Mechanics, physiology, economics, and botany alike, show any craving after mere size to be an ill-considered and unscientific fancy, for which it would be even difficult to find an excuse.

Attention has already been drawn to the fact (page 228 *et seq.*) that natural selection tends to develop the swarming tendency, while the bee-keeper's interest lies in checking this very tendency to the uttermost.

It will be seen, from the plans suggested, that the eggs furnishing queens, in the hands of the expert, are scarcely, in any instance, laid by a mother surrounded in her stock by the swarming fever; and since (if I may be allowed a convenient but, perhaps, slightly inaccurate expression) the mental conditions under which these eggs are laid are likely to reappear, this is of the highest moment. Every faculty or propensity derives force from exercise, and diminishes in intensity by infrequent use. This is equally true of the organs of the body as of the instincts accompanying it. In our coal-mines exist eyeless spiders, the descendants of those carried down, probably, in the fodder of the horses, and which, in the darkness, long years since, had to secure their food by the exercise of the sense of touch. Their eyes, out of use, and never stimulated by the presence of light, have decreased in energy and size generation after generation, until we have their progeny actually devoid of the organ which circumstances had rendered useless. Similarly, if queens be raised, generation after generation, from parents which have never joined in a swarming expedition, and which have been strangers to the stimulus of the swarm fever, it is certain that the disposition to swarm will gradually all but disappear.

The compactness of the brood-nest is a point of more than trifling moment, aiding the bees in maintaining temperature, and the bee-keeper in preserving his brood and honey chambers practically distinct. It is the result, undoubtedly, of selection, and is not dependent upon the environment of the queen. On one occasion here a swarm was hived carelessly, and

did not seem to settle well to work. At my return home, a week after, I found the queen imprisoned between the quilt and the chaff-box and the top bar of one of the frames, her head only being free. The bees had recognised her, and no doubt duly supplied her with food, and so they had remained. At her liberation she walked slowly down, but showed a conspicuous dent in the thorax. Her egg-producing powers were unimpaired, but she had lost the instinct of regulating the brood-nest, never leaving one side of one comb, in which she laid and relaid continually in the same cells until brood appeared, when she moved off to others. The same lack is observable in the fertile worker, which will often lay as many as a dozen eggs in a cell.

But one more point before we leave this question of selection, the importance of which can only be fully appreciated by the bee-keeper who apprehends clearly that nature and art are not at one in the objects sought. Individual variations* in the period of development of queens have affected that period in a remarkable manner. In a state of nature the queen that hatches out first—or, other things being equal, which develops most quickly (Vol. I., page 244)—has the best chance of surviving; and hence, natural processes have, in contravention of some analogies, so expedited the maturation of queens, that they, the larger creatures, develop in about sixteen days, while the workers do not leave their cells till four and a half days later. This selection is an all-round advantage, being not only favourable

* See "Social Instincts of Bees," by G. D. Haviland, B.A.

to the individual, but also to the species, by decreasing the period of necessary queenlessness. But in some matters the individual is favoured to the *injury* of the community at large; *e.g.*, the jealousy of young queens, leading them to fight, and, if possible, kill their sisters, gives the greater chance to the most jealous, or the best fighter; and this has constantly intensified the instinct of queen-rivalry and hatred, until it has resulted in the impossibility of having more queens than one in a hive—a fact favourable to *that* queen, since she alone can leave progeny; but how great a disadvantage to the species! If this single queen be lost in her mating-tour, her colony is doomed to extinction, and the same fate awaits it should she die while no eggs exist in her hive, or even in the presence of these, if no drones are found to fecundate her successor. It is not, then, in relation to the swarming impulse *alone* that art seems capable of improving upon natural processes; and this is as it should be, for man has thus left open to him a delightful field for the exercise and encouragement of his intelligence.

But, it will be asked, of what certain advantage is selecting the queen if the drone is beyond our control? Much every way, but chiefly that in selecting the queen of the present, we select the drone of the future; because the queen is herself by herself the drone-parent, and as she is, so he will be. Opinions have been expressed as to the special influence the drone exerts on the worker progeny, but these are so contradictory that they are valueless. Where a cross-mating occurs, the workers will present every variety

between the race of the mother and that of the father; it seems, therefore, idle to assert that the drone gives colour, size, and temper, the queen working qualities, and so on. The prepotency of both parents is seen in various individuals, for reasons which are at present beyond our knowledge. But it is not fully true that the drone *is* beyond our control. We may secure his presence in the colonies of our selection abnormally early in the year, as already explained, or we may delay our queen-production till drones in stocks possessing queens have been killed, in both ways giving to those of our choice a field cleared of rivals. We obtain drones late by transferring to queenless stocks combs of eggs, so long as our drone-raising queen can be induced, by feeding and nursing, to lay in drone-cells given in the middle of her brood-nest.

But, beyond this, we may secure impregnation at a period of the day when all but our selected drones are at rest at home. Our nucleus, when the queen is five or six days old, is closed up with due precaution, and carried to a dark, cool room, and kept till the afternoon of the second day, when heated, diluted honey is given, and, so soon as the drone wing is no longer heard, the hive is restored to its stand in the full sunlight, and the bees liberated. The excitement set up will bring forth queen and drones (the drones may with advantage be in a second nucleus), and our object will probably be secured. Should we fail, another attempt must be made. The evidence of our success is borne by the queen's body, as described at page 207, Vol. I.

The anticipations that some advanced men amongst

us have entertained, in reference to artificial fertilisation, *i.e.*, the accouplement of the queen by mechanical means, have not, at present, so far as I am aware, been realised, while the prospect has quite lost the hopeful character it at one time possessed. Professor McLain, in a very appreciative private letter to myself, detailed his experiments of some, of which I condense his account. Having hatched a queen from a cell in the charge of bees in confinement, he found orgasm advanced on the sixth day. The next evening, five or six drones were placed in a glass jar, when the queen, dropped amongst them, commenced an "amorous dalliance," indicating that the time for operating had arrived. A drone was removed without alarming him, and sprayed with chloroform, his head snipped off and he pinned back downwards, his abdomen opened, and the testes and seminal sac removed. The queen was then held head and back downwards, by gently grasping the thorax between the thumb and forefinger, and upon her open vulva were squeezed the contents of the seminal vessels. Three drones were employed, and the queen, by a set of muscular movements, seemed to receive the material even with eagerness. The queen, after wing-clipping, was returned, and the bees liberated. Careful examination had shown that there were no drones in the hive, so that the improbable suggestion that she had been fecundated in confinement is inadmissible. Indeed, at this time (October) all drones, normally, had disappeared, the weather being both cold and damp. Twelve hours later, the queen possessed the appearance and action of a fertile mother. Her abdomen

was distended, and she was moving about leisurely, and peering into the cells, while the bees were giving that service rendered to queens when they are eager to stimulate ova-production. The following morning (thirty-six hours after the operation), about 500 eggs had been deposited in worker-cells. In due time, worker-bees were hatched from the eggs, and the queen was still laying (November 25) when the colony was packed for winter. In the meantime, eggs, laid by this artificially-fecundated queen, had two queen-cells raised from them in queenless nuclei. The resulting queens were treated as before, and one laid in worker-cells three days after the operation. Advancing winter prevented further experiments.

It is careful work like this that makes history, but Professor McLain was not actually alone, for another worker was, at about the same period, travelling along similar lines, and, strangely, I was in the confidence of both; so that, instead of experimenting myself, honour demanded that I should do no more than watch results. I refer to Mr. Simmins, who has been struggling with this problem as one of the highest value, if only a thoroughly satisfactory solution be found for it. I have aided him by microscopic examinations from time to time, but in no other way. Had practical success crowned his efforts, a detailed account of his plans would have been necessary, but it is only needful to say that perseverance and ingenuity, having both been brought to bear, show that the necessary concomitants of an alliance cannot be mechanically commanded.

Partial successes are frequently obtained, but these are insufficient. One queen operated upon appeared

to lay in a normal manner, but microscopic examination showed that while the spermatheca was partly charged with spermatozoa, these were not arranged in the surprising order (see Fig. 43, Vol. I.) I have always observed in ordinary cases, but were in endless, tangled confusion; so that the queen, although able (as she did) to produce workers, would be commercially valueless, as her powers would be a most uncertain quantity. The operation is, in addition, troublesome, and demands more knowledge and greater delicacy of handling than one bee-keeper in a hundred could be supposed to possess. I know that some have claimed perfect results since Professor McLain's report appeared—one calling the process easy, and saying that he has 200 queens artificially fertilised; but those who know most of the subject will also be the most reserved in receiving such statements. I do not venture to enter the ranks of the prophets, and I admit freely that failure is constantly the stepping-stone to success, but it is my deliberate opinion that, although artificial fertilisation may be of service to the scientist, it cannot as yet be regarded as having entered the arena of practical apiculture. Fertilisation in confinement appears to me to be more capable of successful accomplishment. What has been done in this direction will, with greater convenience, come before us hereafter, while treating of the various Races and their crosses.

Queen Introduction though so important a factor in modern management, is absolutely an *artificial* process, depending for its success upon an exact adaptation to varied and numerous bee instincts and consequent conditions of temper, the latter being neither

easily discoverable nor absolutely constant in their operation. The problem has, therefore, not unnaturally, been difficult of solution, and productive of opinions no less conflicting than the methods followed are diverse. The Author has a distinct preference, as will be seen in the sequel ; but he desires to represent fairly all that each system can accomplish, and so, in a short historical sketch, will, as far as practicable, give each advocate an opportunity of speaking for himself.

We have recently considered why every colony possesses but one laying queen, and a second is never tolerated in one and the same brood-nest, except in the comparatively rare instance of an old mother in her fading time having a daughter raised, fecundated, and actually laying by her side some short period before her absolute supercession. It is so unusual nowadays to allow a queen to go on to the natural period of decay that "two queens in a hive" is indeed a rare sight, while it hardly bears evidence to the most advanced management. This being so, it is, of course, impossible to introduce a queen to a stock until that stock is already queenless. Experiments having no practical issue, in which the stock, *e.g.*, has been divided by a perforated diaphragm, in order that a second queen might be given to one half, while the old one remained in the other, have shown by their failure that this instinct, demanding a single queen in each undivided brood-nest, cannot be set aside.

Nearly 100 years since, Huber* found that when a

* "Nouvelles Observations sur les Abeilles," Vol. I., page 190, unabridged edition.

queen had been removed from her colony, and the agitation described at page 286 had reached its height, returning her to her children instantly established calmness (a new-born calm) in their midst, but that the substitution of another queen did not produce the same effect. He states that if the alien is introduced into the hive during the first twelve hours which follow the carrying off of the reigning queen, the agitation continues, and the bees treat the strange queen as they would if their proper one were still with them. They seize her, envelope her on all sides, and hold her captive in an impenetrable mass during a long space of time. Ordinarily, the queen succumbs—it may be of hunger or of deprivation of air. When eighteen hours are allowed to pass before substituting a stranger for the one removed, the former is treated at first in the same manner, but the bees which have surrounded her grow weary more quickly, and the mass is, ere long, less dense. Little by little they disperse, and at length this queen comes out of captivity. She is seen to walk off with a feeble and languishing step, and sometimes she expires in a few minutes. "We have seen," Huber continues, "other queens leave, in good condition, an imprisonment which has continued seventeen hours, and finish up by reigning in the hive where, at first, they have been so badly received." But if one waits twenty-four or thirty hours before substituting a stranger, she will be welcomed, and reign from the instant of her introduction.

These early experiments roughly indicate that, while the old mother is only missed, a stranger would be regarded as an enemy, but when despair has

seized the colony, and they realise that their mother has indeed gone beyond hope, another queen may be at once accepted as her substitute. To which must be added that, later on, the bees would, as we have already more than once noticed, start queen-cells, so that the void may be filled, and then again they instinctively refuse to accept an alien.

The impossibility of determining the favourable

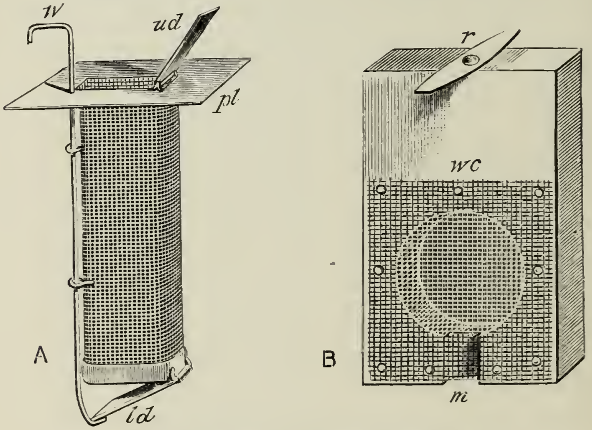


FIG. 86.—INTRODUCING-CAGES (Scale, ½).
A, Raynor Cage—*w*, Movable Wire; *pl*, Rest-plate; *ud*, Upper Door; *ld*, Lower Door. B, Alley Cage—*wc*, Wire Cloth; *m*, Mortise Opening; *r*, Rest-piece.

moment with any certainty practically renders its existence useless; and, indeed, in many conditions of the colony, the favourable moment never appears. Bee-keepers have therefore had to face the difficulty, striving to conquer by plans naturally dividing themselves, as follows: first, wearing out the instinct of antipathy to a mother-in-law, by using some form of cage; second, putting the instinct into abeyance, by stupefying or disorganising, and rendering hopeless;

third, evading the instinct by deceiving the bees in such a manner that no feeling of antipathy is aroused.

First : Caging. This plan admits of an acquaintance being formed while the queen is safe from attack, and generally, after confinement, continued for a day or two—the period varying with changing circumstances—the workers attend her at her liberation with every appearance of attachment.

The cage bearing the honoured name of the Rev. G. Raynor has been extensively used, and is represented at Fig. 86. The rest-plate (*pl*), by lying on the top bars of the frames, or on the edges of the feed-hole, supports, between the combs, the body of the cage, which is about 3in. long. Should there be a queen in the hive to be operated upon, she must first be secured. The cage,* with its lower door (*ld*) closed, is now pushed down between two combs upon which the bees are clustering, when the mother to be dispossessed is run into imprisonment by means of the upper door (*ud*). After twelve hours, a little smoke is given at the entrance of the hive, and the upper door of the cage opened. The queen, disturbed by the smoke, walks out for a little fresh air, permitting the operator to replace her by her successor. Twenty-four hours later, if there be no apparent excitement at the entrance, the lower door of the cage is opened by pushing down the wire (*w*), giving the new queen her liberty. To these recommendations I add, let the release of the queen be made after dark. The modification of the method, when dealing with skeps, is obvious.

* "Queen Introduction," by the Rev. G. Raynor.

The bees may be allowed to liberate the queen themselves, by leaving the lower door sufficiently open to permit of her exit, but plugging the lower end of the cage, to the depth of ½in. at least, with a mixture of honey and finely-powdered loaf sugar. This should be carefully worked up, some time before it is needed, until it is as tough as dough, or it will too quickly soften in the warmth of the hive. This food is commonly called "Good Candy," from Mr. Good, who first compounded it.

Mr. Alley uses a capital introducing-cage, seen at B, Fig. 86, and which he describes* as follows: "Take a block of wood 3in. long, 2in. wide, and ½in. thick, and bore through it a 1¼in. hole, ½in. from one end. Then cut the slot or mortise (*m*) from the hole to the end of the cage or block, being careful not to cut out more than enough to allow the bees to pass through after the wire cloth is fastened on. Now cover both sides with wire cloth, as seen in the Figure; cut the tin rest (*r*) 1½in. long and ¾in. wide, and fasten it to one end of the cage by driving a wire nail through the centre of it and into the block, which it will hold between the frames."

The cage may be used in introducing both laying and virgin queens; these are inserted through the mortise hole, which should then be plugged with good candy. The bees must have been queenless three days before they will thus kindly receive virgin queens. In my judgment, this cage is to be preferred to the Raynor, for a reason which does not seem to have received attention. The queen has

* "The Bee-keeper's Handy Book," pp. 26 and 182.

in the latter, if surrounded by angry bees, no spot where she can for a moment remain without attempted attack, and, although the wire cloth is fine—about fifteen meshes to the inch—no sooner is a foot down than one of the mob is struggling to seize it, necessitating perpetual movement. Feeding is impossible under the circumstances, to which I attribute my not infrequent losses when I gave this cage a fair

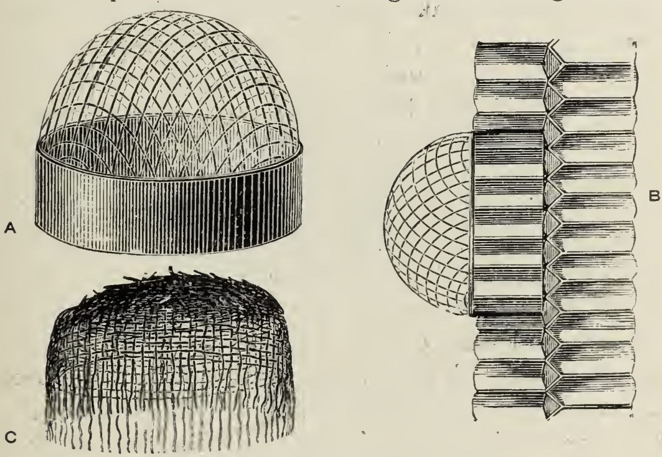


FIG. 87. DOME INTRODUCING-CAGES.
A, Dome Cage, with Metal Rim. B, Ditto, fixed in Comb. C, Benton Introducing-cage.

trial, now many years since.* With the Alley cage, however excited and unfriendly the stock, the queen, on any part of the circumference of the hole, is beyond the touch of her enemies, so that she can rest and sip at her candy if she will.

* Those cages that are closed by a wire, covering a long slot, which wire is removed to give the queen liberty, are particularly objectionable, since the length of the opening by the side of the wire gives the attacking party an easy opportunity of seizing a foot or wing, and working mischief.

One of the oldest and most used—perhaps, for the practical apiarian, the best cage—is the Pipe-cover, or Dome, seen in Fig. 87. It consists of a ring of tin plate, on to which is soldered a dome of wire cloth, with meshes not more than $\frac{1}{10}$in. square. If the queen which we desire to instal be an imported one, the box in which she has taken her journey should be opened under cover, as queens so placed not infrequently take advantage of their new-found liberty by flight. This trouble arising in the open air necessitates remaining in position, as the operator himself has probably been made by the sportive matron a landmark, by which she shall, at her convenience, re-discover the spot whence she took her departure. A little patience will then commonly be rewarded by seeing her return, when, lifting her by the wings, and caging her as explained at page 257, we have her ready for her temporary imprisonment in the hive. Select now a tough brood-comb, and upon a part of it, containing some unsealed honey, after having driven the bees from the spot by smoke, place card and cage; slip away the card with caution—for a tiny leg is soon broken—and then, with a screwing motion, cut the tin rim into the comb down to the midrib, as at B. The Rev. G. Raynor recommends that the bees be prevented from gnawing out the cage by passing a long needle through its base into the midrib of the comb; but I have always found the tin rim to hold securely, the bees attaching the surrounding cells to it. He also advises placing the comb diagonally so that half of it stands outside the hive. I, however, often use, for any purpose requiring command of

the comb, the homely contrivance represented in Fig. 88. It holds a frame of any size, and side pressure does not move it from the perpendicular, while both hands are quite at liberty.

During prosperous times, twelve hours' confinement may suffice, but late in the season three days will frequently be required; and Mr. Root, without exaggeration, says a week is sometimes necessary. When the hive is opened, if the bees are found clustering densely over the cage, and curving their abdomens

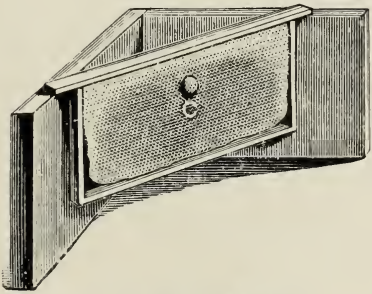


FIG. 88.—SIMPLE COMB-REST.
C, Cage for Queen.

as though determined to sting—encasing the cage, as it were, because they cannot actually encase the queen—more time must be given. If we venture to lift the cage, judging that the bees are no longer unfriendly, or are even paying court through the prison bars, any backing out of the way of the advancing queen, accompanied by repeated touching with a down stroke of the antennæ, may be regarded as a favourable omen. The excessive curiosity and superfluous attention of one or two clambering upon her back, apparently intent on cleaning her coat,

portend no mischief, and the hive may be closed; but should the bees begin to run together and cover the queen from view, she must be again caged, the bees being driven away by smoke. No gloves should be used; they impede the operator, while they save from a really imaginary danger, since bees, under these circumstances, reserve their stings for the object of especial vengeance—our pet queen. It is one of the misfortunes of these cages that, after an apparently contented acceptance of the liberated mother, satisfying the most critical eye, an encasement, without assignable cause, may follow within an hour or two. This is always attended with a good deal of noise and uproar, which generally shows itself at the hive door. If circumstances are suspicious, notwithstanding the fact that any meddling may itself start trouble, it is best to open the hive, and, if necessary, break up the regicidal knot, which may be lifted out with the fingers, and treated to smoke until the queen is visible, when recaging is the only alternative.

Mr. Benton prefers a cage without a rim (C, Fig. 87), made of wire cloth, ten or twelve meshes to the inch. A piece 2in. by $4\frac{1}{4}$in. is rolled round a stick, and sewn with wire at the edges to form a cylinder. The end, cut into slits, and properly gored, is bent inwards to form a roof, into which a piece of warm foundation is imbedded with a pencil, five or six strands at the lower end being then enravelled. With the queen are caged half-a-dozen recently-hatched workers taken from the hive to which she is to be introduced, and her prison is pressed into the comb until the wire points reach the bases of the cells. Bringing the frames to

their proper relative distances, of necessity, so places the comb bearing the cage that the crown of the latter presses against the adjoining comb, so that the weight of the cluster gathering upon it does not drag it from its place. He recommends that the queen be liberated next day about sundown if the unfavourable indications above mentioned are absent. If present, the queen must be left twenty-four or forty-eight hours longer, when it will be necessary to look for and destroy any newly-formed queen-cells, as these commonly bar every effort at introduction by caging. It is also Mr. Benton's practice, upon freeing the queen, to drizzle diluted honey or sweetened water over both bees and combs, and not to touch the hive for two or three days, lest the queen should be attacked.

All dome cages, with the advantages that the queen has both food and rest at command, have yet the defect that the stock must be disturbed, and the bees put into a suspicious temper, at the moment she is delivered over to their attentions. The Peet cage removes the latter objection, and retains the mentioned advantages. It much resembles the Alley without the mortise hole, but with one side only covered with wire cloth. The uncovered side is simply fixed over open honey-cells in the close neighbourhood of brood. The method of affixing is both crude and uncertain. Tin tongues are pushed through the comb, and bent so as to form a kind of rivet. The comb is injured, and the cage cannot fail to occasionally slip, with fatal results to the queen; but, if all goes well, the bees burrow, according to their wont, beneath the wood, making a bee space between it and their comb, and thus they

in two or three days liberate the queen themselves. They reach her one at a time; there is no contagious excitement, and, in every instance in which I have tried it, the queen has been well received.

If a strip of wire cloth, about 4in. by 3in., be bent round two wooden slips $2\frac{1}{2}$in. long by $\frac{3}{8}$in. thick, the cage (Fig. 89) will be formed: this will adjust itself to any inequality in the comb better than the Peet, and may, by the aid of a zinc strip (*z*, C, Fig. 90), be held in

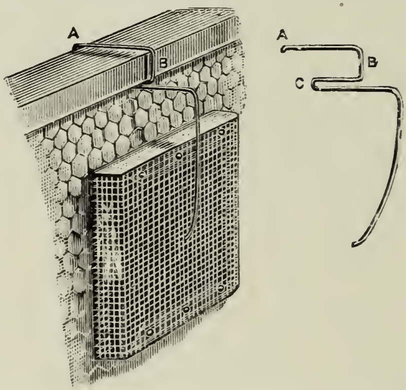


FIG. 89.—CHESHIRE INTRODUCING-CAGE (Scale, $\frac{1}{2}$).

position with perfect security by a string (*st*); but the best form of fixing is undoubtedly the wire shown in Fig. 89. The turned point A just grips the opposite angle of the top bar, while the projection C passes beneath the latter, and so the cage is held with a gentle pressure by a weak spring, which nothing can dislodge. The workers (*w*, C, Fig. 90) gnaw their way into the Royal box, and find at the same time an exit for the queen. Mr. Holland has arranged and combined the introducing-cage and postal-box in such

an ingenious manner that the queen arrives with all that is needful ready placed for her introduction. The cage (A) is round, with a returned edge about $\frac{1}{4}$in. broad. It is packed for travelling as at B. Two auger-holes (*ah, ah*) are run consecutively from the

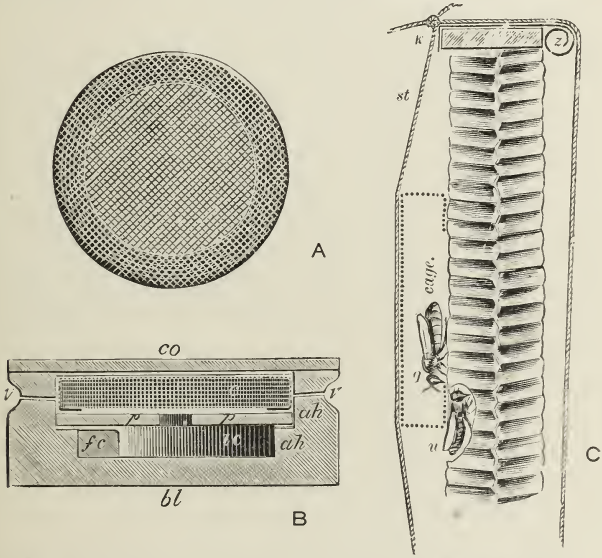


FIG. 90.—CHESHIRE-HOLLAND CAGE AND POSTAL ARRANGEMENT (Scale, $\frac{1}{2}$).
A, Cage (Front View). B, Section of Cage as Packed with Queen and Workers for Post—*c*, Cage; *ic*, Inner Chamber; *fc*, Food Chamber and Food; *v*, *v*, Ventilating Holes; *co*, Cover; *bl*, Block; *p*, *p*, Partition. C, Cage Fixed to Comb by (*st*) String—*k*, Knot; *z*, Zinc Strip; *q*, Queen; *w*, Worker liberating her.

same centre into a block (*bl*); in the deeper, smaller hole, Good candy* is placed, under a cover (*fc*). Above

* For this and similar purposes Viallon candy (so called from M. Paul Viallon) may be employed; and it has the advantage of containing a very small amount of nitrogenous food, while it long remains moist and soft. To make it, take 12oz. of powdered loaf sugar, 4oz. of brown ditto, one tablespoonful of flour, and two of honey. Mix well; add enough water to make into a stiff batter, boil for one minute, and continue to stir during cooling.

stands a partition (*p*, *p*), with a central opening to give the bees passage-way. Upon the partition, after about two dozen attendants have been passed through the before-mentioned opening, the cage (*c*) carrying the queen is placed; the wire is added, and the cover (*co*) fixed down. Ventilating holes (*v*, *v*) are provided, opening into a depression (an idea borrowed from Mr. Benton), so that they cannot be closed by lying in contact with letters in the post. The inner chamber is cosy and warm in chilly weather, but if the bees feel it to be stuffy, they can pass into the cooler, more open quarters of the cage itself. This cage, which I believe would practically never fail, would delay overmuch the exit of the queen, if very tough combs were used. The result may be quickened by cutting diagonally, with a thin and narrow knife, through the cell walls at one spot beneath the edge of the queen's quarters; or delayed entrance to the bees may be given by cutting as small a circle as possible through the midrib, operating from the opposite side of the comb to that upon which the cage is fixed, the partly-separated portion remaining at first as a plug: the bees, gnawing away at the damage, liberate the prisoner. This plan is followed with the "Betsinger Cage," and acts perfectly, although it permanently somewhat damages the comb.

The cage has still its ardent advocates, and it is not likely to be soon abandoned, although its greatest defect is inherent: it is, that it is a cage—a strange and unwelcome excrescence, which, in itself, excites the antagonism of the bees (for they hate any intrusion into their brood-nest), and attracts their attention

to the strange queen when they are least likely to be amiable; but this criticism does not apply to a form of introduction which, though of the nature of caging, seems to belong equally to our third head. It has long been known that if a queen-cell, containing a nymph, be opened at the base, so as to remove its occupant and to give place to the queen we intend to provide, a little thinning of the end, in which a large pinhole is made, will convert it into a very successful introducing-cage, care being taken that the bees do not tear it open above, either closing it well by wax-sheet, or protecting it by Mr. Doolittle's guard (Fig. 79). In 1874, Mr. Wood, of Nyborg, Denmark, exhibited some imitation queen-cells, cast in wax, which were to be used in this way, but occasional failures caused them to be regarded with disfavour. Mr. Simmins frequently gives a virgin queen, by using a cage somewhat like the Doolittle (Fig. 79). It is made of coffee-strainer, and is cylindrical in form, 1½in. long by a bare ½in. in diameter. The end is closed by pressing the edges of the cylinder upon a thin piece of foundation, thus cutting out a plug. The queen is placed within, head downwards, and gnaws out and escapes, much as she did from her natural cradle. The conditions being so like normal ones, the stranger behaves as though at home, and is generally received without question.

Stupefying by the fumes of smouldering puff-ball, or *Lycoperdon*, in order to introduce alien queens, has long been practised, the Rev. G. Raynor employing it successfully when the art of queen-introduction was in its infancy. Since it is much more troublesome

and less certain than chloroforming, while its disagreeable odour hangs about the stock for some time, I shall content myself by giving a precis of Mr. Jones' experiences with the latter. Drop* a dry sponge into the fire-barrel of the smoker, then a sponge wetted with chloroform (a teaspoonful), and another dry one on the top of this in the nozzle, when you are ready for action. Proceed to the queenless colonies, and puff in the chloroform at the entrance (as in the act of smoking), say, for quarter of a minute. Then pass to the next, and so on, for about two minutes. Return to the first hive, give a few more puffs with your chloroform smoker, and let your queen run in. Repeat this until you have gone over all those you at first puffed. The bees have thus about two minutes in which to get sleepy before the queen is introduced. If the operation be performed in the middle of the day, and the bees are returning from the fields, a third dose in a couple of minutes is given, so that the new arrivals may be kept quiet. Mr. Jones claims not only to have introduced, without a failure, fifty queens in fifty minutes, but to have taken the worst cases where fertile workers were present, and the most obstinate queenless colonies, and to have "never missed." The queens introduced were usually virgins, and this makes the success the more conspicuous. Mr. Jones was not the first to use chloroform, but we are indebted to him for a simple and innocent plan—the anæsthetic, as applied by him, being distributed to all parts of the hive equally, killing none of the bees, yet remaining for some time in sufficient

* *Canadian Bee Journal*, Vol. I., page 390.

amount to keep them in a sleepy condition, out of which they emerge so gradually that the queen behaves as though at home, and no encasement follows.

During the honey season, queens may, in most cases, be successfully run in after very vigorously smoking at the entrance. The smoke of tobacco appears to me to be particularly objectionable, but is usually preferred for this purpose on account of its stupefying effect. The evening, as the light is failing, is the time for the operation. Then all the bees are at home, and none escape the dose. The bees should be aroused as little as possible in removing the queen to be displaced, and, whilst they are suffering from the noisome blasts, her successor placed within the entrance, and driven forward by an additional puff. In introducing virgin queens thus, forty-eight hours' previous queenlessness is desirable.

Under our second head we have yet to consider the effect of hopelessness, in addition to disorganisation. The Rev. G. Raynor has put this so well in his paper that I prefer to follow so excellent an authority *in extenso*: "In their normal condition, bees will always show fight on the introduction of strange bees to a well-stocked hive, whether by the entrance or otherwise. But deprive the same bees of their possessions—combs, brood, and honey—and they will unite with any others presented to them without a struggle. In the case of colonies, therefore, in fixed-comb hives, such as skeps, the bees are driven out by the ordinary method, and their queen is removed. By driving, the bees are thoroughly subdued, and all the

fight is taken out of them. The hive from which they were driven is now placed upon a board or cloth, and raised in front, and the bees are shaken upon the board. As they run into the hive, the alien queen (with accompanying bees, if any) is dropped into their midst, and all joyfully enter together.

"I have experimented on this plan with many hundreds of colonies—condemned bees and others—and can truthfully assert that it has never failed in a single instance. The same method is easy of application to colonies in frame hives, by removing their queen, and shaking or brushing the bees from their combs, and allowing them to run into an empty skep placed on the stand of their hive. The combs are returned, the frame hive takes the place of the skep, out of which the bees are shaken as before, and the new queen is dropped amongst them as they run into their former abode. Neither syrup nor scent is used, as I have found them quite unnecessary; and the operation is performed in a more cleanly manner without either, there being, moreover, less danger of attracting robber bees. The method may be practised at any time; indeed, I have introduced queens thus in mid-winter, by removing the hive to a warm room."

When bees have fully realised that they are irremediably motherless, they will commonly accord a friendly greeting to any queen offered them; and many times, when I have found a stock in this state, I have simply put a fertile mother on the top bar of one of the frames, and watched results. As a rule, a few bees make inquiries, and she walks down, a most welcome guest. Singularly, such stocks furnish both

the most easy and the most difficult subjects for re-queening experiments, for, in rare instances, when all the bees have become old, they not only utterly refuse to accept a queen, howsoever presented, or to raise queen-cells, but they, in a sort of dementia, will destroy the latter if they are given to them, together with all eggs and young larvæ—this, possibly, because they have partially lost the faculty of tending brood. A case of this kind occurred to Mr. Hunter, and my incredulity was only overcome after I became a party to the experiments made with the colony.

A discussion, conducted with too much positiveness on both sides, has recently been provoked in the *British Bee Journal* by a correspondent stating the following as a "law" which knows no exception:

"When bees have no queen, nor means of rearing one (*i.e.*, have no eggs, unsealed brood, or queen-cells in their hive), they will always accept a fertile queen at the flight-hole, or dropped in from the top. Providing they have been in such a state for forty-eight hours, it matters nothing how old the bees are, or how long they have been queenless, and it makes no difference how heavy the queen is with eggs, or how light, so long as she is fertile, and given alone, without caging." I have already noted that this is very usually true, but have given evidence that the asserted absolute uniformity of its application cannot be conceded. The "law" is, however, so far constant as to be of considerable value; but the recommendation to remove the queen, and all combs containing eggs or brood (putting these into other stocks), and give the strange queen forty-eight hours after, is, as we shall

presently see, an invitation to follow a long and circuitous road when a short and direct one lies open.

The third class of plans present, like the others, several varieties—*e.g.*, Mr. Sadler* asserts that if, after the abstraction of the old queen, thin sugar syrup be scented with oil of peppermint, and poured between the combs, from a vessel with a small spout, a stranger then put on the top of the bars and wetted with the same syrup will be at once accepted. Here the queen, in her misfortune, is likely to welcome the attentions of the workers in cleaning her, and so secure for herself a good reception; and this, in my judgment, is a more important factor in determining success or failure than the scenting. This method is, in some respects, like that of rolling the queen in warm honey, in a teaspoon, and dropping her in at the feed-hole, which is reliable during a honey flow, but most uncertain, as well as unsuitable, in early spring or late autumn; and although I cannot cite proofs of failure of the method in which Mr. Webster has so much confidence, I still think it hardly likely to be more uniformly successful. In addition, the objection to daubing either queens or bees with syrup or honey is worthy of serious consideration, for the spiracles (page 33, Vol. I.), especially those near the insertion of the wings, are liable to damage by clogging.

Bee-keepers sought long for some system of queen-introduction which should be immediate and practically certain, and some progress had been made in this direction, when Mr. Simmins announced a method which, if successful, left nothing to be desired.

* *British Bee Journal*, Vol. XIV., page 332.

A slight modification was afterwards made in the *modus operandi*, which now stands thus: Remove the queen from the hive that is to receive the stranger, placing the latter, at dusk, in a warm situation, quite alone, and without food, and so keeping her for thirty minutes. Then lift, at one corner, the quilt of the hive to which she is to be introduced, driving back the bees with very little smoke, and at once permit the queen to run down. Close the hive, make no examination for forty-eight hours, and leave the operation until so late that a lamp is necessary when the queen is introduced.

It was evident that a plan so simple and expeditious, if only reliable, would confer a boon upon bee-keepers, the value of which could hardly be exaggerated. Honest trial has proved it, in my experience, to be all but uniformly successful, and that, too, under circumstances in which the usual methods invariably fail, as two or three typical cases will make clear. Receiving a Cyprian queen from Mr. Benton, in one of his boxes, I introduced her, in the manner above described, to a Syrian stock ten days queenless, and which had many queen-cells near maturity. About forty-five hours afterwards, when the bees were getting quiet, her ladyship was found, looking none the worse for her ten days' journey, saucy, and at home, and, for love of her, the bees had pulled down all their Syrian queen-cells. An albino was now given to a stock possessing a fertile worker, such being usually considered an *insuperable* impediment to the introduction of a queen; but she was accepted without question, and, at the permitted time of examination,

had laid a considerable breadth of eggs. A second albino had to have a home created for her, so I divided, on the afternoon of August 19, a very strong stock of Carniolans; and, because the queenless half seemed excited, and in danger of being robbed, I, as a precaution, removed, about 7.30 p.m., a queen, of less value—at least, of less rarity—than the albino, from another stock, and introduced this queen, in thirty minutes, to the half above-mentioned, while, at the same time, the albino took her place. The two stocks were thus queenless about four hours and thirty minutes respectively. When the hives were inspected, both queens were laying.

Three South African queens have been received into this country; two have perished dismally in attempts at introduction by caging. The third was first introduced direct by Mr. Simmins himself, then passed on to me, on October 26th last, and again introduced, in the same manner, on a biting night, to a stock queenless six hours only. In my hands she wintered, and went back to Rottingdean in the spring, and the third time passed the ordeal without a shadow of a hitch. These facts would appear sufficient to dispose of the oft-made statement that successful direct introduction necessitates two or three days' previous queenlessness; while it is evident that queen-cells (although it would be wise to remove them, if possible) do not cause failure, and even that the fertile worker succumbs before a laying mother thus given. Following up the question, I tried many dozens of experiments, and found that, by Mr. Simmins' method, it was quite easy, not only to

introduce, but to get one queen to *lay*, in half-a-dozen distinct hives in a single week; for the bees not only receive the queen, but, when they have lost their proper mother but a little time, appear utterly unaffected by, or unaware of, the change.

My trials have, I believe, embraced almost every supposable difficulty and variation both in season and in the condition of the stocks, and show the system to be practically perfect, as I have to record with laying queens a single failure only, and in that I have no evidence at all of the way in which the ill-fated one vanished. To the colony in which the mishap occurred I subsequently gave a black queen, to try the temper of the enemy. She, being satisfactorily installed as mother, was deposed one afternoon, to make way, in the evening, for a Cyprian. The bees came out rather strongly when the corner of the quilt was lifted, which necessitated more than the customary slight puff of smoke. Half-an-hour later, hearing, as I fancied, more than the usual noise of fanners at the door, fear of losing another first-grade Cyprian determined me to examine the stock by lamplight, and so, if needful, rescue my pet queen from the mauling I feared she might be experiencing. The bull's-eye lantern being placed near by, the combs were removed one by one, when certainly less than a dozen bees took wing, and, in the centre of the brood-nest, the Cyprian turned up, walking about in a normal way, as though she had been there a month.

The question may fairly be asked: How is it that an alien is thus received, so that she begins laying forthwith (if eggs have matured in her ovaries),

precisely as though no change had been made in her abode? The reasons appear to me to be these: First, her half-hour's solitude and fast make her anxious both for company and food. When she is inserted, instead of exhibiting nervousness and suspicion, any society is welcomed in preference to lonely seclusion, and her keen appetite brings her boldly to her new-found associates, asking hospitality; and so she takes the first step as the rightful mother. Second, it is dark. There is no need to guard against robber bees, for none are in flight. The sentinels have ceased to ask the pass-word, and all within the camp are friends; and then, she *must* belong to the hive, for she did not pass the entrance at all, but is found near the roof—and thus the bees are cheated into kindness, where a knowledge of the truth would make them wild with rage.

The condition of the queen has, however, somewhat to do with the bearing of the bees towards her. She must not come in "a questionable shape." If she be out of laying, she may disappoint the colony, and so be overthrown, even after she has been accepted; while want of personal cleanliness will make her safety doubtful. The Italian queens of former days were sent, with, perhaps, 200 workers, in boxes of about thirty-six cubic inches capacity, each containing a small comb of store. These had frequently, at their arrival, an odour not of sanctity, since the attendant workers had become distended beyond endurance. This fact greatly increased the difficulty of introduction, for they who keep every cranny swept, and themselves as clean as new pins, would not be likely to accept with much

grace an unwashed mother-in-law, grimed and travel-stained, addressing herself, in most unpleasant fashion, to the olfactories of her new feeders and attendants. The older bee-keepers will corroborate this position, as they will remember how frequently a stock would accept a despised black after slaying a highly-prized Italian.

Let me here point out, in a parenthesis, how very much Mr. Benton has facilitated the introduction of foreign queens by his admirable postal-box (Fig. 91).

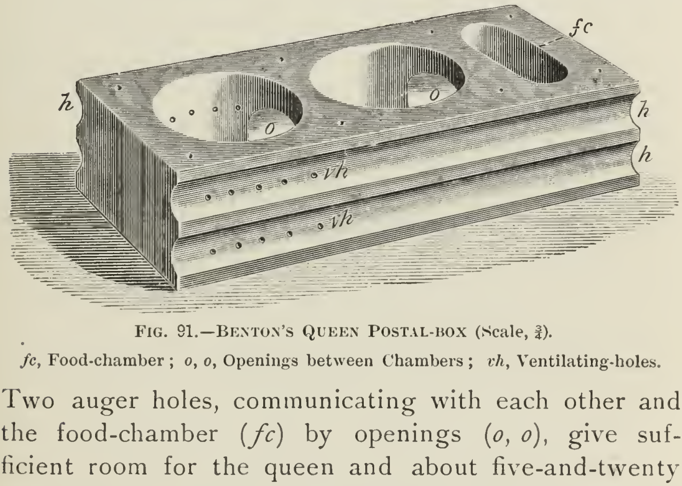


FIG. 91.—BENTON'S QUEEN POSTAL-BOX (Scale, ⅔).
fc, Food-chamber ; *o*, *o*, Openings between Chambers ; *vh*, Ventilating-holes.

Two auger holes, communicating with each other and the food-chamber (*fc*) by openings (*o*, *o*), give sufficient room for the queen and about five-and-twenty attendants. The food, consisting of Good candy, is covered down by a piece of thin foundation, beneath which it remains without soiling, although immediately accessible to the bees. The ventilating-holes (*vh*, *vh*) are made at the bottom of the hollows (*h*, *h*), so that, as previously explained, other packages cannot close them. Paper is neatly placed over the top, and upon

this is tacked a thin wooden lid. The bees have a certain control over their temperature by using the first or second opening, as circumstances dictate. The food supplies no material to collect in the bowel, and so the little captives arrive in a perfectly cleanly condition; and the ease with which a journey is endured will be best seen by outlining a circumstance referred to by Mr. Benton.* On August 16th, 1886, he packed, amongst other queens, a first-grade Cyprian to myself. Upon her arrival in London, she was returned by the post-office officials as "not mailable," and thirty-three days after her removal from her hive she was again at her starting-point. The bees were then "in fine order—but two workers dead, rest bright and lively, queen as fresh as though just taken from the hive; the box without a speck, and with no bad smell; food about two-thirds consumed." She was allowed five days in a stock, and then forwarded to me a second time, *viâ* Munich, and was introduced, by Mr. Simmins' method, upon the evening of her arrival, after fifty-one days' travelling, and she is now laying splendidly in a hive labelled "Madame la Voyageuse."

To return to our subject. Some use a dome cage for keeping the queen her thirty minutes in solitary confinement; but I prefer a loosely-corked, wide, short test tube, which must, of course, be kept up to 70° Fahr., or thereabouts. Placing the tube in the trousers pocket will save the queen from chill while we are going to the hive; and as the tube is approximately upright, and she cannot climb the side, we have her

* *British Bee Journal*, Vol. XIV., page 461.

exactly under command, and well in view, especially if a slip of white paper be pasted down one side of the glass. The corner of the quilt lifted, the inversion of the tube rolls her out, and she is on the top bar of the frame in a moment; while, with the dome cage, she is likely to cling to the edges, and, perhaps, in the pale light of the lamp, elude us for a few moments, so that the stock gets a needless and undesirable amount of disturbance.

In summing up my own impression with regard to varied re-queening systems, I have little hesitation in saying that the plan of direct introduction last described, if properly managed (and, with so much simplicity, mismanagement is hardly possible), will give a lower percentage of failures than any of the usual forms of caging, while the trouble involved is not a tithe of that caging demands. No time is lost, either to queen or bees, and the operation, being completed at a stroke, places no burden on the memory of the operator. In addition, no drug is used, nor smoke in nauseating volumes, and there can be no suspicion of injuring, even temporarily, the health of either bees or queen; while, if one pleases, every queen in the apiary may be changed from one hive to another with no greater loss than one half-hour's ovipositing.

An attempt has been made to deprive Mr. Simmins of the honour of giving the method to the world of bee-keepers. Then Watt did not invent the steam-engine, for he built on Newcomen; and so on in endless chain, for almost every invention is interlinked with some part of the legacy of thought, the heritage of every age. But he is an inventor who,

out of that legacy, brings some new application which gives us a power we did not previously possess. Direct introduction, as taught by Mr. Simmins, has saved me queens, time, and anxiety, and I feel pleasure in expressing my indebtedness.

In the height of a honey flow, when troops of young bees are gnawing out, and the old ones are all too busy in the fields to intrude overmuch into the brood-nest, queens may be lifted off their combs and placed down at once amongst the unsuspecting youngsters of another stock, whose queen has just been carried off, perhaps to exchange places with her successor; but we have not been dealing with such special conditions, and transfers like these had better be left—by the novice, at least—to those whose experience will grasp the needful conditions for a commonly risky experiment. Recently-hatched grey bees will agree with any queen, and if it be desirable to keep the latter in her travelling-box while her original attendants are failing, new ones, if only quite young, may be given to her from any stock with perfect safety. It may aid the learner, also, to remark that stocks that become queenless, especially if through a failure in introduction, are more fussy and noisy under manipulation than usual, and that this behaviour will be, to an expert, a good sign of their condition.

Ere closing this chapter devoted to queens, some notice must be given of those pseudo-queens, called fertile workers, which sometimes appear, and especially in those hives that have been long hopelessly queenless. One or more of the workers, without external change, will commence ovipositing in an irregular

manner, laying, generally, many eggs in a cell, sometimes as many as a dozen being found confusedly heaped together. Some writers have erroneously stated that several eggs in a cell is conclusive evidence of the presence of a fertile worker, overlooking an exception of not infrequent occurrence in modern apiaries. Should a good queen be taken from a strong stock, and placed in a nucleus where she has only a small number of cells to receive her abundant eggs, she will, having supplied all, go over them again and again, until the appearance presented by the amateur ovipositing of the fertile worker is produced. A young queen raised in a nucleus will often do the same thing. The fertile worker's eggs, for reasons fully argued in Vol. I., page 223, produce drones only, which, being formed in worker-cells, oblige the extension of the latter by extraordinarily prominent and convex sealing, as found in the hives of drone-breeding queens. The drones thus produced are smaller than the average, but they have virile powers (see page 207, Vol. I.).

The theory advanced by Huber, and supported by Dzierzon, that fertile workers have, by accident, received some royal jelly through occupying cells adjacent to queen-cells, needs no refutation, for we have already shown that "royal jelly"—so named in ignorance of the facts—is given to *all* workers and drones in their earlier larval stages. These little plagues have turned up in my stocks where no queens have been produced. They are the counterpart of the laying workers of the semi-social bees; but the manner in which their normally latent power of ovipositing is brought forth admits of no easy ex-

planation. The emotions of the higher animals have often remarkable physical influences. Amongst many like facts, it may be cited that buck hares have been known to suckle a litter left by a doe, and a similar function has been performed by a negro* under the stimulus of strong feeling. It would appear that, in the beehive, the desire to have young to nurture brings the potency to generate progeny, though its incompleteness is fatal. The poor bees, aware that something is wrong, constantly strive to raise queens from the eggs the counterfeit is providing; in effect they secure but a dead drone, in a queen-cell which frequently has a most abnormal length. I have measured such, built by Tunisian bees, exactly $1\frac{1}{3}$in. inside, while $\frac{9}{10}$in. is about normal (see E, Fig. 43). The fertile worker ruins the colony, yet to detect her is next to impossible; perhaps not one bee-keeper in a thousand has ever recognised a specimen. Removing the hive to a distant point, brushing off all the bees, and allowing them to fly back, will generally lose the little pest, as, not having flown previously, she will probably get into the wrong hive, to pay the usurper's penalty. Providing the colony (where she or they are at work) with frames of eggs, until all the nursing capacity is fully occupied, will cause these pseudo-queens to subside, and is, I have found, the best method of treatment.

Some races are far more prone to develop fertile workers than others, and in this respect the South

* See "Mental Physiology" (Dr. W. B. Carpenter), and "Principles of Physiology" (Power), p. 969.

Africans would appear to have the pre-eminence; and, unfortunately, their workers visit other stocks to such an extent, that these pests are exceedingly likely to put themselves in evidence at any part of the apiary during any temporary queenlessness. A Ligurian colony in the Rottingdean apiary, that had been deprived of its mother two days previously, was found to contain quite a number of South Africans, the progeny of the queen referred to on page 346. One of these workers was receiving court in a ring of attendants. As she was lifted from the comb, five workers refused to leave, gathering on my fingers, caressing her, and offering food. These followed to the operating-room, and continued to fondle the detached thorax precisely as in the case of a true fertile mother. Her ovaries were finely developed, even more so than those represented at C, Fig. 42, Vol. I., possessing about fifty ovarian tubes each, and carrying eggs in every condition. It was, to me, most extremely interesting to note that the stomach was absolutely free of pollen, containing only the semi-transparent fluid so distinctive of the queen, and thus affording the completion of the evidence of the truth of the theory respecting queen-feeding I advanced at page 83, Vol. I. In another queenless stock, visited the same afternoon, a South African worker was seen in the very act of ovipositing. She was seized with her abdomen still inserted in the cell, and dissection immediately revealed a pair of ovaries about one-fifth the size of those of a true mother.

A queenless nucleus of Carniolans, standing next the South African stock, furnished a third fertile

worker, indicated by her race being apparent, and known as a fertile worker by the attentions paid her by the surrounding bees. Her ovaries were in like manner developed. The stomachs of all three contained the same character of material, while other South African workers had only the usual aborted ovaries, their stomachs showing, under the microscope, multitudes of pollen grains.

The strange fascination these pseudo-mothers had for the workers was extremely remarkable, for the dissecting-knives, the fingers, the spilt juices, &c., could not be freed of the stray bees in the operating-room; and in this the pseudo did not seem at all less attractive than the true queen. Since the former has not copulated, the idea is dispelled that here can lie the reason; but as virgin queens, and those out of laying, are less acceptable to bees, and so not so easily introduced as those with active ovaries, it would appear that some emanation from the latter has about it the, to us, unintelligible charm, the effect of which is, under certain circumstances, extremely singular. If, *e.g.*, a box which contains a laying queen, or which has very recently contained one, be placed over the frames of a hive having no fertile worker, and which is hopelessly queenless, the bees will soon begin to congregate upon it, while a gentle wing-flapping spreads through the entire colony. Then, by raising the box and allowing time, the bees may be gathered suspended from it almost after the manner of a swarm. Bees so behaving may be trusted with a new queen immediately.

CHAPTER VIII.

THE APIARY: ITS ESTABLISHMENT AND GENERAL MANAGEMENT.

Selecting a Locality—Pasturage, and Desirable Conditions—Operating-house: How to Clear of Bees—Separate Stands—House Apiary—Purchasing Stocks—Condemned Bees—Bumping—Capturing Stray Colonies—Bee-hunting—Foods and Feeding—Syrup and Syrup-feeders—Crystallisation of Food in Comb—Dry Sugar Feeding—Candy Flour Cake—Artificial Pollen—Milk and Egg Feeding—Water—Packing Bees for Long Journeys—Spring Stimulation—Spreading the Brood—Autumn Feeding—Robbing: How to Stop—Bee-tent—Moving Stocks—Uniting—Displacing Queens—Register of Operations.

BUT little will be said in reference to the locality of the apiary, since the amateur determines this point by that of his own dwelling, while he who makes bee-keeping his profession will hardly need advice in making a choice which, after all, must not be absolutely settled by productiveness in honey; climate, surroundings, communication by railroad or otherwise, nearness to a possible market, and many other matters requiring consideration.

No position will offer a combination of all advantages, while it is true that scarcely a spot exists in which bees may not be made, at the least, to secure their own living; for even in overgrown London (except in its very densest parts) a modicum of stained surplus may be obtained, though, unfortunately, accompanied by a most objectionable excess of sooty propolis. Rather than one great breadth of an especial blossom, it is more desirable to secure a long, and, as far as practicable, an uninterrupted, succession of good honey-yielding plants. Be it remembered that many timber trees (see Vol. I., page 262, *et seq.*) in early spring most helpfully encourage breeding by supplying pollen, and also providing honey in quantity not to be despised; while fruit farms, small orchards, or even villa gardens, with their peaches, plums, cherries, pears, and apples, followed by the small fruits, are of the highest possible value. Wild flowers innumerable, and later blossoming trees, notably horse-chestnuts, keep up the succession, when, should the melilots abound, and the trifoliums and sainfoins make broad fields fragrant, the little labourers may bear home a harvest to their storehouses, so that there be not room to contain it. The lime groves, spreading their choice perfume, and merry with the hum of ten thousand busy wings glistening in the July sun, gladden the heart of the bee-keeper, who is happy indeed if still he may look on to late wild flowers, bramble, wild thyme, and dwarf thistles, to be succeeded by the late-born riches of the heather harvest.

Almost every locality has some specialty, and a distance of a mile or two will often carry us from a good to an indifferent district, or the reverse. A rich,

deep soil yields, with heavier leafage, fewer blossoms, but more honey, than a thin one, but the honey is less aromatic. A valley is to be preferred to a high land, because the bees are not only screened from damaging winds, but the empty ones easily rise along the hill-sides, while those laden glide downwards to their homes. The seaboard, or the bank of a wide river, is not desirable, for there the hunting-ground is on one side of us only, and, in windy weather, many a weary burden-bearer, carried from her track, will drop, never to rise again. The seed farmer is a most desirable neighbour, while the careless husbandman is an unintentional helper, for some weeds, although the farmer's bane, are the bee-keeper's opportunity, the wild mustard or charlock (*Sinapis arvensis*), *e.g.*, in some localities yielding more to the little nectar-seeker than all the other plants to which she has access put together. Extensive sheep-runs on fine grazing land unfit a district for bees, since sheep crop so closely that scarcely a blossom escapes: but on semi-waste tracks the stock the land is capable of supporting will not be thick enough to keep down a multitude of wild flowers, which may bring a harvest to the bee-farmer, while some of these, rich in honey, are actually shunned, and, with unwitting kindness, left to spread by the grazing animals. Districts already well supplied with bees should, if possible, be avoided, because less honey (*cœteris paribus*) will be gathered, unwelcome drones may too often set their mark upon our stocks, and disease contracted in the colonies of the unskilful is likely to be perpetuated and communicated, now and again, through robbers, to our own apiary.

My readers will not need to be warned against a common mistake—that the flower garden is the bees' cornucopia. As an American humourist says, "the bee can get over a very high fence," and the plants which grow close to its hive door are not much visited, its instinct rightly leading it further afield. If each forager applied to the blossoms nearest home, how much time would be lost in dipping into nectaries already rifled of their sweets! Cultivating a *few* melliferous flowers near the hives, after the manner of some amateurs, is scarcely more likely to increase the weight of the supers than growing wheat in a flower-pot is likely to cheapen bread. True, the nearer to our stocks rich forage lies, the greater will be our results; but all included within a circle two miles in diameter, having the apiary for its centre, may be regarded by the bee-keeper as his forage ground. Certainly, his bees will travel to a much greater distance, but the wear and tear and the time occupied in the longer journeys detract considerably from the net result.

A district may undoubtedly be considerably improved by carefully sowing in waste places honey plants, which will, when established, scatter their own seeds—borage, melilot, and white clover, *e.g.*—but devoting land to a honey crop is generally a doubtful investment; for, even in America, where land is cheap, or only half-occupied, and the population sparse, it is a debatable point whether planting for honey actually pays.

A gentle slope has advantages over a dead level, and, if this runs to the south, so much the better,

while on the north, and to the east and west of the north, should lie a windbrake, either of evergreen trees, some building, or a fence. Intruding animals should also be kept at bay, Mr. Root especially ostracising dogs and fowls. Of the latter he says: "A flock of enterprising hens will make more disorder in a few hours in a well-kept apiary than the owner can restore in half a day." He who would deny Mr. Root's statement must be an ardent poultry fancier, and as blind as love can make him. Yet fowls may serve a purpose in an apiary, and at Rottingdean I remember seeing a troop of chickens whose function it was to kill earwigs, and wonderfully had they learnt their part. Whenever a hive was opened, they were in attendance, and caught up the disturbed insect intruders as they dropped to the ground. Should a bee settle on the feathery jacket, or appear threatening, the beak had it and threw it down, and then gave it a second grip before it could recover sufficiently to take wing; so that the chicks, educated, no doubt, in the school of adversity, rarely received a sting.

The possessor of even a few hives will find his comfort enhanced by a small operating-house, in which combs may be kept, section-boxes prepared, extraction performed, &c. The utmost care will not prevent bees finding their way where there is so much to attract, every opening of the door, in certain seasons, admitting a few visitors; while some operations necessitate the carrying of stray bees into the interior. The windows should, therefore, be so contrived that the unwelcome guests may be removed or permitted to escape. For the first, the sashes may

be swung on central pivots (*p*, A, Fig. 92), so that bees collecting on the glass, whither they are drawn by the light, may be placed on the outside by giving the sash a half-rotation, and fixing it in its place by a bolt. After the bees have wearied themselves by fluttering on the glass, they usually collect in little knots above the sash, whence they must be brushed if they are to be removed; but by adding to the sash the guards *g*, *g′*, which may be of perforated zinc or rough wood (although in the latter case drainage should be permitted), the bees will congregate at *c*,

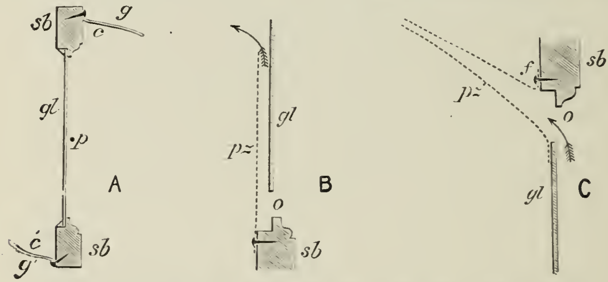


FIG. 92.—ARRANGEMENT OF WINDOWS IN OPERATING-ROOM. Sections.
A, Revolving Window—*p*, Pivot; *gl*, Glass; *sb*, *sb*, Sashbar: *g*, *g′*, guards; *c*, *c′*, Position of Clustering Bees. B and C, Windows with (*o*, *o*) Escape Slots—*pz*, *pz′*, Perforated Zinc; *f*, Fixing; other Letterings as before.

and will, in consequence, be carried out to *c′* by the aforesaid half-revolution of the window.

Bees, in striving to find an escape, fly up the front of the pane, and then drop to the bottom of it, so that, if the glass (*gl*, B) do not meet the lower sashbar (*sb*) by about an inch, the captives there escape, while bees on the outside may be prevented from entering by covering the opening with perforated zinc (*pz*) about six or eight inches wide, leaving a bee-space between it and the glass. This works

capitally, and I feel certain, although I have never tried it, that a flat exit tube of perforated zinc (*pz'*, C) at the upper part of the sash would be a great advantage. The weight of the tube, if it be fixed at *f*, would hold it against the glass, and no rain would be carried inwards. The forms B and C have the advantage of being automatic, but the constant draught will sometimes be a nuisance, when wooden slips may be temporarily inserted in the openings (*o*, *o*). This precaution must always be taken before liberating queens from boxes in which they have travelled.

In this country, the hives are almost always placed on detached stands in the open; and if in more rows than one, the quincunx order is most suitable, *i.e.*, the hives of one row are opposite to the spaces between the hives of the next. This gives the bees a less interrupted flight-line, and saves the operator from the annoyance of standing in front of any stock. In planning an apiary, it is by no means necessary that the hives should face the south or south-east, as some say—the well-being of the colony being, apparently, so little affected by this, that authorities may be found pleading for the advantages of each point of the compass; and where hives are somewhat crowded, placing the alighting-boards in different directions considerably reduces the difficulties arising from excessive proximity. Thus, if four hives be placed in a close line, running from east to west, and face, in the sequence, east, south, north, west, flying queens would not be endangered, and the bees would be hardly likely to grow too familiar — a common cause, unhappily, of quarrel,

both with bees and their masters. It is highly desirable, however, that the hives stand level, so that the frames hang plumb, or awkward combs will be built. Weeds should also be kept clear of the alighting-boards and around the front of the hives. To this end, a thick layer of sawdust is recommended to be laid on the surface of the ground; but spent tan is even more effectual, and less likely to be disturbed by wind.

Single stands admit of greater facility, in many manipulations, than is possible with the house apiary, in which the operating-house gives accommodation to the hives, whose mouths are openings in its walls, the latter also carrying the alighting-boards. Many bee-keepers would prefer a combination of systems, keeping the bulk of the stocks on separate stands, and a few disposed around the operating-room. The main difficulty with all bee-houses arises from the young bees, which, if a hive is opened on a sunny afternoon, or in bright weather after rain, frequently fly out in numbers, and, not knowing the legitimate entrance, will insist on returning to their home by the road by which they left it, and if they are driven out of the house and the door closed, will, in despair, collect in a sulky little cluster. Mr. Root says of these, "they are seldom lost, for they will usually be allowed to enter the hives nearest the door;" but this weakens their proper stock, and is apt to puzzle a novice sorely.

Square or oblong houses would not safely accommodate so many bees as octagonal ones, because a long string of hives on a side would be likely to trap flying queens into the wrong entrances, to their all but

certain destruction. The hives may be arranged in two tiers, and, supposing three to stand in line on each side of the house, the central one of the three will need a back only, since the proximate sides of the two outer ones will be party walls. The entrances should be kept as far as practicable apart, by making them at the outer angle of the outer hives; while painting the alighting-boards of unlike colours may be of service. My own bee-house long since came under the chopper, but Mr. Root thinks well of the house apiary, and sums it up thus: "It is always sheltered and dry, and, if the building is kept painted, the hives will always be in good repair; this is quite an advantage over outdoor hives. The hives can be much more quickly opened, as they need no other covering than the chaff cushions in winter, and a single sheet of cloth in summer.* Secondly, surplus honey, either extracted or comb, can be removed in less time; for we have only to remove it and store it in the centre of the room, instead of the laborious carrying that has to be done with outdoor hives. Also empty combs, combs filled for destitute colonies, empty frames, frames of section-boxes, and, in short, everything needed in working about the hives, may be stored in the centre of the room within arm's reach. Furthermore, we can handle the bees, and do all kinds of work with them during rainy and wet weather, when the outdoor hives could not be touched. Nay, further, we can handle the bees by lamplight after the duties of the day are over. We have repeatedly made new colonies thus, to avoid robber bees that were so annoying in the

* In our climate this would be inadequate.

day-time during a dearth of pasturage." This is all true, but bee-keeping is essentially an outdoor occupation, and few would willingly exchange the fresh air and sunlight of the open for the stuffy heat of a bee-house. The loss of freedom in choosing where every stock shall stand, and the inelastic character of the house apiary, make it undesirable, except as an adjunct to the separate stand system.

In starting an apiary, is it very desirable that those with no experience go slowly. The acquisition of three or four stocks will furnish abundant ground for gaining solid practical knowledge, which will at first grow more rapidly in the management of a few than in the confusion of many colonies, for the memories of most men are not sufficient to retain and systematise the numerous points bees bring before their attention until these by practice have become familiar.

Either purchasing swarms or stocks, or taking condemned bees, will enable us to make a beginning. The swarms should be acquired early, and ought not to weigh less than 3lb. The lowest prices will be quoted by cottagers owning skeps, but we must wait in uncertainty until their swarms come off naturally; and, as the skeps are small, the swarms will be light. The packing may be unskilful, and our bee-keeping may begin in annoyance. It is best for the novice to apply to a reliable dealer, and purchase his bees by weight. Paying too heavily for an especial race is not desirable, as a queen or queens may be subsequently purchased, and made to head strong stocks, in a few weeks, by the nucleus system. In buying stocks of cottagers or inexperienced persons, it is

most important that evidence should be given of their freedom from disease (see Foul Brood), or pitiable failure may await us. In selecting skeps, smoke, and turn up, choosing those that have swarmed the year before, and possessing, consequently, a young queen. Give preference to large, flat plates of comb, in which drone-sized cells are not over-abundant (especially if it is intended to transfer to frame hives). Casts of the year before will give these desirable conditions, but their hives should be full of comb. In the autumn the bees ought to be strong in numbers, and in the early spring there should be at least four or five seams of them. We may get evidence of the presence of a fertile queen by finding sealed brood. Drive the bees up between the combs by smoke, and separate the combs somewhat with the fingers, to get a view of the cappings. It is only exceptionally desirable to buy stocks in frame hives, on account of the difficulty of transit and the higher cost. Colonies and artificial swarms in changing hands should not travel less than a mile, or many of the bees will go back to their old quarters and be lost.

The miserable practice of sulphuring bees still continues in some districts. In the autumn, the colonies of medium weight are selected to stand the winter. The heavy ones for their honey, and the light ones because they would starve if left, are "taken up"—*i.e.*, a hollow is made in the ground, to receive at night a lighted rag, which has been dipped into melted sulphur, when the skep is stood over it. The bees, technically called "condemned bees," feeling the stifling fume, creep into their cells, or drop into the

"pit," and, when all are dead, the combs are removed, the honey drained out, and the combs "rendered" into wax. The dead bees in the cells are an impediment to the cottager, and so he is willing to give, or sell for sixpence, or at most a shilling, per skep, the "condemned," upon condition that they are driven (see Driving, page 233), and the skep, with its comb, returned to him. He loses nothing, and is saved the duties of the executioner.

The population of three, or even four, skeps, put together, then transferred to an empty hive, and allowed six frames furnished with guides, and fed until 20lbs. or 25lbs. is reached, will usually make an excellent stock in the following spring, as no drone-comb will be built. In driving, care should be taken to secure the best queen; *e.g.*, take first a cast of the year, or a stock that has thrown a swarm, and let the queen run up, for she is young; then into the same skep drive swarms catching the queens, that must have been laying two seasons at least. The poor folk from whom these bees come are, unfortunately, too little instructed to see that their skeps no longer gain honey when income drops as low as expenditure, which is frequently some time before gathering actually ceases. They, in consequence, defer taking up until so late that this plan cannot be satisfactorily carried out, although I have had condemned bees do excellently which were not hived till the last week in September.* In an apiary in going order, combs

* Where heather abounds, the honey harvest closes so late, and so abruptly, that condemned bees cannot well be built up unless aided by stored combs.

are always at command in the autumn. The later condemned bees by their aid may receive a ready-furnished home, and so be converted into wintering stocks at once; or they may be utilised in strengthening stocks not otherwise populous enough to safely hold on till spring shall once more greet us: they must be added with the precautions given under "Uniting."

Taking condemned bees is excellent practice, and small difficulties often have to be surmounted which greatly instruct the bee-keeper, while he can afford to experiment, as the loss involved in failure is inconsiderable. The troubles arising from robbing and fighting necessitate care and expedition, and so have latterly led many bee-keepers to adopt a plan named by Mr. Lyon "bumping," instead of ordinary driving, which, in cool weather, is a comparatively sluggish process. In cases in which the combs are to be removed, it has long been the practice with myself, and I should suppose with many others, to abandon the thudding when bees have driven badly, and break or cut and break out the combs, sweeping off the bees. Mr. Lyon* goes further, by making no attempt at driving, his initial step being a loosening of the contents of the skep by a bump or blow. He recommends that the operation should be preceded by providing some large vessel to receive the removed combs, and a sack, or its equivalent, to cover them from robbers; then, with a little smoke, to save the operator from attack, the skeps should be so plugged with grass thrust in lengthways that the bees are prevented passing, while not deprived of air. After

* *British Bee Journal*, Vol. xiv., page 314.

giving the skep to be bumped a good puff of smoke, it is turned up, and, being held a few inches from the ground, at an angle of 45° to the horizon, with the faces—not the ends—of the combs towards the operator, he rapidly pushes the whole from him, striking the edge of the top on the ground, so that the combs break from their attachments. If the combs are very old, the blow must be a sharp one; if tender, gentleness will do it. The sticks commonly running through the skep (page 243) should be drawn out, with a screwing motion, by a pair of pincers, or, if no projection be discoverable, notched through with a penknife, or cut with a pair of pruning-shears, so as to liberate the first two combs, after which they will give no trouble. The combs will generally break away close to the top of the skep, for reasons which I have already explained (page 223). Mr. Lyon says: "Replace the skep on its stand—upside down, of course—lift out the combs one at a time (a penny gridiron* is very convenient to put down between the combs to raise them on), brush the bees rapidly off both sides with a wing† into the skep, put the combs into a pan, and cover them with a sack. As each skep is emptied of its combs, replace it on its stand right side up, resting the edge on two or three stones, and leave it for the bees to cluster. Do not forget to liberate the other bees before leaving. The whole operation need only take five or six minutes, against twenty or thirty for driving." The details as to packing, transporting, and hiving, have already

* Most, like myself, would prefer the fingers.

† The usual, but a most inconvenient, instrument. See pages 134 and 259.

been given (pages 136 and 261). In travelling from spot to spot in taking bees, all paraphernalia should be reduced to the smallest possible compass, for nearly everything must be carried, the cottagers rarely being able to supply a want. Where practicable, I would, however, have a spare skep and a large, light board, which should occupy the old stand, the latter catching the brushed bees. The first skep finished, the board is removed, and carried to the next stand, after the adherent bees have been shaken off of it.

Few bees are killed by this process, and the queens only rarely suffer. Should the latter be required for any purpose, they can easily be preserved by putting them, as found (and they are commonly seen during the brushing process), into wire-cloth* cages, and fixing each with a French nail into the roof of the skep—it does not matter which, so long as each lot has one.

"Bumping" is, no doubt, very useful for the purpose now under consideration, but is unsuitable to warm weather or combs containing brood, and is, moreover, subject to a miscarriage, in that the combs, if stored with honey in the attachment-cells (as they will be if the bees have been pushed for room), break through the store an inch or so from the top, bleeding badly, and hopelessly gumming many bees. Cutting the side attachments, bending down slightly, freeing the end comb, and then moving the rest singly, will prevent this misadventure, but will occupy slightly more time than the "bump." Carbolic acid, in addition to smoke, is

* I have used dome cages, fixed on to a piece of a section box by an indiarubber band. The wood has a neat, round hole previously made in it, passing the nail freely, but not the head.

a great help in taking condemned stocks. Its watery solution, wiped over the floor-board, will make the bees leave the latter and cluster more quickly in the skep, which should be propped high to avoid its fumes.

Capturing colonies which have located themselves in undesirable situations, occasionally provides the means of augmenting our stocks. The statement that the plan of procedure will depend on circumstances is not very helpful. The difficulties are of one kind, and so may be best explained by relating in short two expeditions in which the writer endeavoured to restore to civilised courses bees that had hoped, perhaps, to bid adieu to the trammels of bar-framers, the dull uniformity of foundation, and the innovation of section boxes, by hieing away to the seclusion of a double-brick wall in one case, and the roof of a church in the other. The double wall formed part of an old structure and through an aperture eight feet from the ground, the result of decay, the swarm had evidently entered, and had utilised an interspace only $4\frac{1}{2}$in. wide from front to back. A bricklayer cut out some front bricks to lay the colony open to view, and this work acted like the hive-beating in driving, completely quieting the bees, which made no remonstrance during the dismantling of their home. The bricklayer soon lost courage, and so I had to trench upon masonic mysteries, lifting out the honeycombs as it was possible to free them. These I found about 3ft. 6in. deep, and supported at intervals by cross bricks; but, unfortunately, as we came upon the brood-combs, the queen, with the greater number of bees, retreated into the recess, beyond reach. All the brood-combs, by

cutting, trimming, and fixing into frames, were made ready for the hive; but even the adherent bees, except the very young, flew from them and returned to their now concealed companions.

The queen was not with us, while nearly all the bees were with her, and quite inaccessible, unless so much of the wall was to be removed as to endanger its safety. In this dilemma we fixed the frames, with their brood-combs, as nearly as possible in true position, and in the spot the brood had previously occupied, nailing up over all a gardener's large mat. So soon as quietude was restored, the bees, with their queen, returned to feed and warm their young. The next morning the mat was lifted with as little disturbance as possible. All were at home again, putting the house in order. The hive to receive them stood against the wall, just under their old entrance. Frame after frame was lifted down, the queen, in due course, making her descent with the rest. The few that took wing soon learned the position of their comrades, and the colony was established in its new quarters with but very little loss, and yielded a fine super at the end of the summer. The main point rests in the manner of capturing the queen, by restoring, for a time, the combs, to which she will infallibly return, when their second removal is too rapidly and quietly accomplished to give her an opportunity of eluding us.

But to our second case. The three or four colonies of the roof of Great Hadham Church—the descendants, doubtless, of one—had behaved so badly, that further forbearance was impossible. A swarm was sent out not only on Sunday, but on the morning of

a confirmation, and, audaciously entering the church window, clustered on an ornament not far from the pulpit; but, to fill up the measure of their transgressions, one reckless bee from this cluster committed the sad indiscretion of stinging a bishop, and so brought well-deserved banishment on her whole tribe. Not long after, ladders were raised, and the Author, unaccustomed as he is to elevated positions, was peering down between the slates as the saucy insects were travelling in and out through four or five openings. The master builder in attendance came to receive directions, but a gust of wind, common at such altitudes, nearly carried away his hat. His rapid movements in preventing this catastrophe produced a worse, for five or six bees, possibly expecting retribution, regarded his quickness as a menace, and took aim at his uncovered scalp, when he retired discomfited. A practical breach was soon made, and pailful after pailful of honeycomb, which at length fairly filled a large saucer-bath, was the first instalment of the booty. The brood-combs followed, but, as before, the bees retired, and had to be gained by the expedient previously explained. After the final removal of the bees the following morning, the hollow in which this colony had existed for several years was filled with coke saturated with carbolic acid. This last substance is so excessively nauseous to the genus *Apis* that no fresh swarm would be likely to choose this spot as a dwelling-place. The other families, now the way had been shown, fared no better than the first; for a volunteer, clad in armour, attacked, defeated, and captured another detachment, without receiving damage, at a point where more climbing ability than I

possessed was required, whilst his clothing grew so sweet and sticky, that not a few of the enemy became attached to him.

Despoil, as far as possible, the store-combs first, so as to destroy cover; and, if needful, restore the brood-combs after their transference to frames. Remove these as early after the return of the bees as practicable, when the disturbance and fright will cause the worried insects to note the locality you have chosen, and there remain.

As bee-hunting, properly so called, can be practised only in sparsely-populated countries, the barest outline must suffice. The operation consists in tracking colonies that have settled in the woods, localising themselves in hollow trees. When bees obtain abundance of honey from blossoms, they pass that in the bulk unnoticed, so a "bait" is then useless; but in the autumn, when the natural supply fails, the bee-hunter —provided with a small, bottomless box, whose lid is a glass slide, and which contains, in its upper part, diluted honey in a miniature feeder—repairs to the forest, and pops his box over any bees he may find foraging. Closing the bottom by his hand, the bees rise and feed. Having placed his box in the best position for seeing them at their exit, he draws back the glass slide, and lies down, so as to put them, if possible, between himself and the sky. When they leave, they carefully mark their location, and then start, indicating by their line of flight (the "bee-line") the position of their home. The bees, returning for a new load, are carried by the hunter a certain distance along the line they have struck,

when the process is repeated. The first workers are joined by others, and at last the nest is detected. Sometimes, the tree is felled, ruining the colony possibly, the "bumping" being too energetically administered; at others, the climber, having pronged irons strapped down the side of the leg and beneath the boot, brings down the nest somewhat in the manner previously described.

Feeding, intelligently managed, does more than anything else, in an uncertain climate like ours, to increase the bee-keeper's harvest; and we have now to consider the requisites of foods given as substitutes for, or additions to, natural stores, consisting of honey and pollen, to which, in certain cases, water must be added. The first of these is practically non-nitrogenous, and may for the moment be regarded as sugar made liquid by water, as its sugar gives it its food value, constituting it a producer of heat and force. Sugar syrup properly prepared, on this account substitutes it so completely that nothing is left to be desired. The curious compounds once advocated are no longer employed, while such additions as ale and porter are now known to be not only useless, but actually dangerous, since they contain nitrogenous substances in combination with ferments, and these, when added to sugar, are extremely likely, especially in the warm hive, to cause fermentation of the honey and its associated pollen, blowing the latter out of the cells in a frothy mass, to the great detriment of the stock.*

* I have had two cases under the microscope in which alcoholic fermentation from the cause given was in rapid progress in most of the cells, the *Torula cerevisiæ* (yeast) showing considerable activity, while the honey had been made watery by destruction of its sugar.

Proper preparation of the syrup is most desirable, for a reason presently apparent. It would appear to be the common idea that sweetness in all dietary articles is due to the presence of a substance which is identically the same, whether revealing itself to the taste in the grape, in honey, in milk, or in the sweetmeat of the confectioner: but the error is a grave one, for the word "sugar" is generic, and applied to a class of bodies having, with a common likeness, well-marked differences; and, in the examples cited, the sugar of each differs from those of all the rest. The sugar of our tea-table is named by the chemist "saccharose," and is usually derived from the sugar-cane, although its source may be sorghum, beet, or maple, while it is also found mixed with other descriptions of sugar in many fruits. The characteristic with which we have here to do is the facility with which it crystallises into oblique, six-sided prisms. It is, on this account, sometimes distinguished as crystallisable sugar. If a strong* syrup be made of it by boiling with water, the sugar will re-crystallise either as the syrup cools, or, subsequently, as the water evaporates. If it be used in this form, it will solidify, or, as the sugar-baker calls it, "grain," about the feeders and appliances; and, if any of it drop upon the bodies of the bees, it will dry, in appearance, like so much chalk, which the bees will be very slow to remove; and, even if it be stored, it may, especially during the cold of winter, crystallise in the cells. This can be effectually prevented by adding

* 3lb. of sugar dissolve in 1lb. of cold water. Syrup of this strength will form no crystals on cooling.

to the syrup, while boiling, a small quantity of some acid, changing or "inverting" it into non-crystallisable sugar, identical in character with the sugar of honey.

This change is very readily effected: when cane sugar is taken into the mouth, the saliva immediately induces the transformation; boiling slowly does the same. The sugar-refiner would have to raise his syrup to 230° Fahr. did he not carry on the process of evaporation in what is called a vacuum pan, in which 150° is quite sufficient. He thus saves loss by largely preventing the change of his crystallisable into uncrystallisable sugar. We see this very matter in the case of a fruit tart; if sugar be added by the cook before baking, the heat and the acid of the fruit transform the saccharose into grape sugar, or, more exactly, into a mixture of dextrose and levulose. The flavour is more agreeable and natural, but more sugar will be required, since two measures of saccharose have as much effect on the palate as five of grape sugar. Cane sugar is changed into the latter, in our case, as the first step towards assimilation, which is perfectly identical with what ordinarily occurs with the bee. The secretion, or nectar, of most blossoms consists of cane sugar, and is converted, by addition of the salivary juices (see pp. 80, 100, and 263, Vol. I.), into dextrose and levulose in the act of sucking. The alteration is a chemical one, and involves the addition of a molecule of water; so that, strange as it may appear, 342 parts of saccharose become 360 of the dextrose and levulose before mentioned.

If, then, the bee has the power of making the transformation, why, it may be asked, be at the trouble of effecting it? Why not feed cane sugar direct? The answer is three-fold—first, in most forms of feeders, crystallisation is a practical nuisance, fixing parts intended to move, and keeping asunder surfaces intended to meet; next, the transformation is a physiological saving to the bee—a matter, as I take it, of importance, at least where large quantities of syrup have to be rapidly converted with comparatively little other work to be done, as in the case of condemned bees; and, lastly, where crystallisable sugar is rapidly stored, the conversion is very imperfectly performed, and considerable crystallisation in the cells is frequently the result. The syrup which is carried over the ligula and between the maxillæ and labial palpi (page 96, Vol. I.), as is always the case where liquid food is presented in bulk, largely escapes the action of the salivary secretion.

The general practice of bee-keepers is in favour of converting the sugar into the uncrystallisable form, by the addition of an acid—a thick syrup being made by boiling for a few minutes, with each 4lb. of sugar, 1 quart (or 40oz.) of water and about half a tablespoonful (or ½oz.) of vinegar. Stirring, so as to prevent burning, is important. This syrup, as hereafter explained, is suitable for autumn feeding, while, during the spring and summer, double the quantity of water would not be excessive, if the object be the raising of brood or the building of comb. Should the syrup crystallise during use, it may be re-boiled with a little

more acid; for the vinegar is an uncertain quantity, as its effect depends upon the very variable amount of acetic acid it contains, and tartaric or citric acids may well replace it: $\frac{1}{4}$oz. of either being quite sufficient to convert, with ten minutes' boiling, 8lb. of sugar.

Instead of either of the foregoing, 40 drops of sulphuric acid may be used to the aforesaid 8lb. of sugar, the acid being, if the bee-keeper so desire, removed, by the addition, with careful stirring, just before taking from the fire, of a little powdered chalk, which is formed into calcic sulphate, to settle during cooling. Sulphuric acid in this amount is, however, not injurious, and may even be an advantage (see "Diseases").

Salt is often recommended to be added to syrup for bees; and it is stated that they have a craving for this substance. I am disposed to regard this idea as a mistake, and water containing salt I have found neglected where water free of it was at hand, this being especially true if two sources of supply are given within the hive. The bee-keeper can do no harm by adding salt sparingly to his syrup, but he will find it difficult to give a reason for the practice.

Dark, and otherwise inferior, honey, because not marketable, may often be used as bee food with economy; but honey is not so desirable as sugar syrup, as its aroma excites neighbouring stocks, and is likely to induce robbing. In times of scarcity, bees will follow a promising scent with astonishing resolution, and I have known quite a number to descend a chimney 25ft. long because wax was being melted on the fire beneath.

Neatness and convenience demand some receptacle for the syrup to be kept about the apiary, and, perhaps, for this purpose, nothing is better than my syrup-can. Its spout (*sp*, Fig. 93) is covered with perforated zinc, to prevent bees entering to their destruction, while the lid cannot be inadvertently left open ; it is slotted and provided with a well to receive the shovel (*sh*), which, when in position,

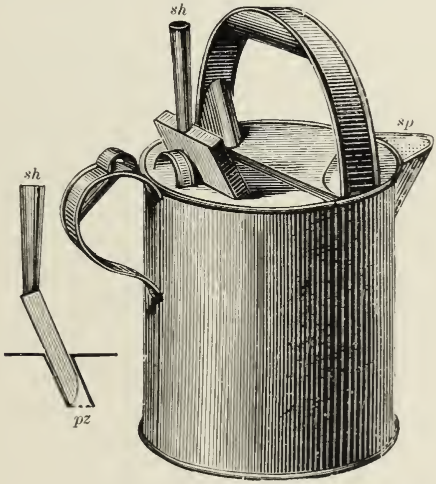


FIG. 93.—CHESHIRE SYRUP CAN.
sp, Spout ; *sh*, Shovel ; *pz*, Perforated Zinc.

drains the syrup remaining upon it through the perforated zinc (*pz*). Some makers have improved (?) upon this form by putting a tube spout, provided also with narrow openings to stop the ingress of the bees, by which the can occupies more space, while it cannot be cleaned within. In the form in the Figure, every part inside is accessible to the finger ;

and this is necessary, for foreign bodies in the syrup soon close the small openings in the spout. The most durable substance for such a can is zinc, but the syrup must be kept from contact with it (see "Extractors"). This can readily be managed if we first heat the metal, by holding the can in water at a higher temperature than that at which wax melts (150° Fahr.), and then, being careful that the interior is dry, paint with liquid wax.

In these days of science it is hardly necessary to explain that, if a bottle with a wide mouth be filled with syrup, and a fine canvas tied over it, it can be at once inverted without the contents escaping, because of the upward pressure of the air. If the bottle be turned over slowly, the syrup will commence to flow out at the lowest part of the canvas, because the air will enter at its highest. This cannot be thoroughly prevented, however rapidly the inversion be performed, unless some flat surface, such as the bottom of a plate, be first put over the canvas, and held in position until the inversion of the bottle has been completed. If the latter now be placed over the feed-hole (*fh*, Fig. 7) of a skep, the bees quickly, without chill, and without leaving their cluster, draw away the contents, by the passing of their tongues through the meshes of the canvas, and air, in bubbles, passes in to supply its place. A far neater way of applying this principle is by using a small board about 5in. square, having a circular hole rather less in diameter than the neck of the food-bottle. Upon this may be fixed fine perforated zinc, that known as Braby No. 6 being best. Such a feeding-stage is suitable for the frame

hive where it stands above a hole in the quilt, or for the skep by being fixed upon its crown, where long screws will hold into the straw with a tenacity few would expect. The leak of heated air between the wood and the irregularities of the skep must be stopped by some luting, and a ring of dough, placed around the feed-hole before the stage is pressed into place, is all-sufficient. The shovel (*sh*, Fig. 93) is used in putting the filled syrup bottle into position. The shovel is placed over the mouth of the latter, and the whole inverted as at A, Fig. 94, when not a drop of syrup escapes—*i.e.*, if the bottle was fully filled. The elasticity of the air in a half filled bottle will cause a little leaking. Standing the shovel over the hole in the feeding-stage, the bottle is held by one hand, and the shovel quickly slid away from under it by the other, when, as before, the syrup is taken by the bees thrusting their proboscides up through the perforations. In lieu of the shovel, although with less convenience, a bricklayer's trowel, or even a piece of tin turned up at one end, may be used.

It is most important that no bees be admitted from other hives to regale themselves around the bottle. Our hive covers should be made, if possible, proof against them; but in cases where these are wanting, a calico bag, large enough to slip over the feeding-bottle easily, with a child's large bead necklace (costing 1d.) sewn into its hem, so fits down to the hive top that no inquiring bee can steal a single sip. Many would prefer a wooden box-like case, covering the bottle, but it does not do the work better, while it is more costly and more cumbrous,

and incapable of accommodating itself to irregularities. Students of rigid economy (and even those well-to-do who, in the philanthropic spirit, instruct their poorer neighbours, should be such) will find that tin cans (B, Fig. 94)—now so abundant that they may be regarded as waste—make excellent feeders. The lid should be placed over the end grain of a piece of hard wood, to prevent its buckling, and then, with a bird-cage maker's bradawl (a pointed awl), fine holes should be pierced. If the can be now filled with syrup,

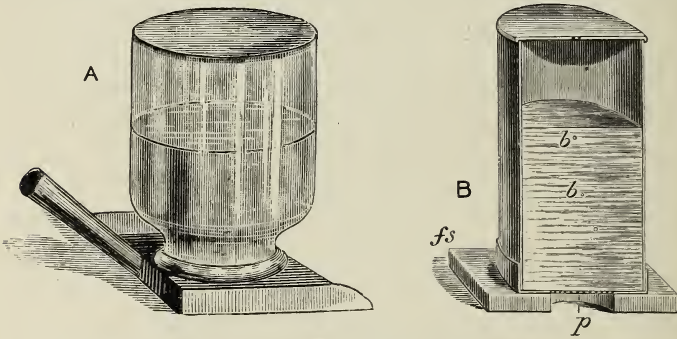


FIG. 94.—APPLIANCES FOR TOP-FEEDING.
A, Shovel and Food-Bottle. B, Section of Tin Can Feeder—*p*, Perforations in Lid; *b*, *b*, Air-bubbles; *fs*, Feeding-stage.

and the lid placed on, it can be inverted without mess or waste, and with no disposition on the part of the lid to drop off, it being only necessary to keep the can perpendicular. It is now stood on the feeding-stage (*fs*). A disadvantage applies to it, and equally to the nearly obsolete bottle and canvas. When it is lifted, the bees escape by the feed-hole, while many are brought away adherent to the feeder. This can be entirely obviated by nailing wire-cloth over the hole, when it is practically equal to, and

considerably resembles, a popular American feeder (Fig. 95), consisting of a tin can, the edge of which is returned so as to hold an indiarubber ring (*ir*); within this fits a cover (C) of coffee-strainer, having a cup upon its inner centre, to receive the end of a coiled spring (*sp*). When the feeder is inverted, as at B, the cover is held in position by the spring, but is easily depressed by the finger, so that the syrup may be poured in. When released, it flies back into place; and now the whole is turned over, ready for standing over the hive. To prevent the

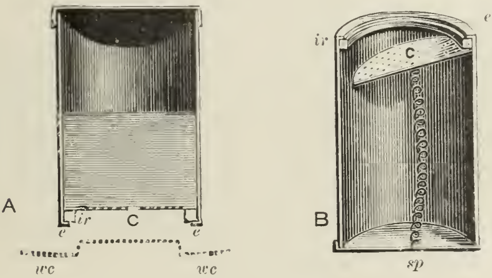


FIG. 95.—CAN FEEDER, in Section (Scale, ¼).

A, Feeder in Position. B, Feeder as held for Filling—*ir*, Indiarubber Ring; *e*, *e*, Returned Edge; C, Perforated Cover; *sp*, Coiled Spring; *wc*, Wire-cloth.

escape of the bees, a piece of wire-cloth (*wc*) is laid over the feed-hole, and is raised in the centre, so as to allow the bees to get close up to the coffee-strainer (C). The whole permits of being taken to pieces immediately, in order that it may be cleansed.

We have now before us the general principles involved in, perhaps, every form of bottle-feeder, except those that attempt to regulate the supply by a wick fitting with adjusted tightness into a small opening—a plan which is too uncertain in its action for

the practical apiarian. Many years since, I endeavoured to superadd some means of regulation, and devised a stage which has been the parent of the large number of rotating feeders now in use. Firstly, I displaced perforated zinc by vulcanite plate, because the latter is at once a substance not affected chemically by any description of food, and a splendid nonconductor of heat. It can be, moreover, easily cut to shape in a warm room. I give the original form, which I think, in some respects, is still superior to every other, since its cost is nominal, it can be

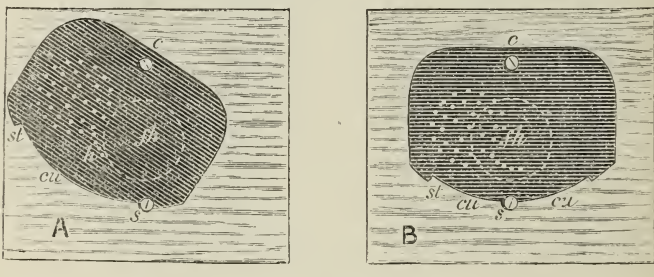


FIG. 96.—CHESHIRE FEEDING-STAGE AND VULCANITE PLATE, (Scale, ½).
A, Food Cut Off—*c*, Centre Screw; *fh*, Feed-hole; *h*, Outlying Holes; *st*, Stop; *s*, Screw to meet Stop. B, Food at Half Supply—Letterings as before.

worked with any wide-necked bottle, large or small, is incapable of getting out of order, can be cleansed or absolutely disinfected most readily, and admits of every gradation between the slowest and very rapid feeding, as the holes in the circular arrangement can be increased in number as may be desired.

The vulcanite plate, on its wooden block, is represented at A and B, Fig. 96. The curve *cu* has for its centre the screw, the hole for which, like all the others, is most conveniently made by a redhot

wire or hairpin, the burr being afterwards scraped off. The dotted circle (*fh*) indicates the opening in the block which stands exactly over the feed-hole in the hive. The perforations are so drilled that, when the stage is turned as far to the left as the screw *s* meeting the stop will permit, the holes are all of them out of the reach of the bees; but when it is desired that they taste of our sweets, the stage is turned towards the right, when the outlying holes (*h*) begin to pass within the area of the feed-hole, at first permitting but a single bee to obtain food; then follow, as the rotation is continued, those in circular arrangement, until, when the opposite stop is reached, all are open, giving a bountiful banquet. These movements are, of course, made when the food-bottle is in position. The vulcanite should be roughened upon the under surface, by deeply scratching it with a sharp knife, so that the bees may have foothold. Should the plate be curled, place it in hot water, and then press between two pieces of flat wood till cool, when it will remain as desired. The vulcanite is so close to the bees that they have not to disconnect themselves from their companions in order to reach it; and if the syrup be made cold by a chilly atmosphere, the non-conductivity of the stage will keep the space beneath it from being cooled. Metal stages are here greatly at fault, often making feeding by the bees in cold weather impossible, the food rather tantalising than helping, since contact with the almost icy zinc or tin would benumb at once.

It is clear that the can B, Fig. 94, can be made into a regulated feeder by piercing the holes excentrically

(to one side) on the lid. If, in addition, brown paper *soaked* in wax and rosin be waxed on to it, and the holes opened out with a pin, we have a feeder which, in practice, is nearly equal to the most expensive. The advantages of regulated feeding will be considered later on.

One of the most perfect top feeders was introduced by the Rev. G. Raynor, which, embodying

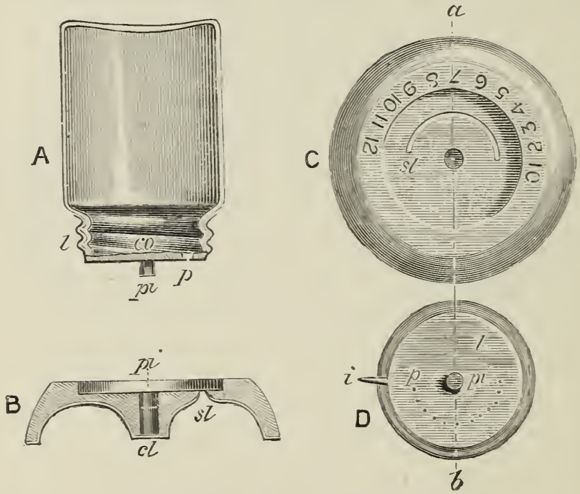


FIG. 97.—THE RAYNOR FEEDER (Scale, $\frac{1}{5}$).

A and B, Sections through the Line *a b* of Bottle, Cover and Stage—*l*, Screw-Lid; *co*, Cork; *pi*, Pivot; *p*, Perforations; *cl*, Cloth Lining; *sl*, Slot. C, View from above Stage. D, Ditto of Cover and Bottle Neck—*i*, Index; other Letterings as before.

some of the features of that last described, introduces others. It consists of a bottle (seen in section at A, Fig. 97), which holds nearly a pint and a half. Its neck is fitted with a screw-lid (*l*), lined with cork to prevent leakage, and perforated by twelve holes, set in a semicircle. On its centre, a pivot (*pi*) is fixed.

The stand is made of hard wood, with a circular depression to receive the bottle neck, and a hole to centre the pivot. It is hollowed beneath, so that the bees may extend their cluster upwards, holding on to the cloth (*cl*) which covers the under side, and feed from the perforations, standing over the slot (*sl*) in perfect comfort, even in the chilliest weather. The slot, $\frac{1}{8}$in. wide, lies beneath the whole semicircle of perforations when the index (*i*) stands at 12, so that many bees simultaneously regale themselves; but turning the bottle begins to place the holes, one after the other, over the unslotted part, and so reduce the number reachable, as indicated by the index and figures—the latter marked on the stage—until 0 is reached, when the supply is actually cut off. The fact that bees from four or five frames can pass at once into the dome is occasionally an advantage.

Top feeding is most expedient in cold, bad weather, for even strong colonies, if at such times in need, can hardly break from the cluster in order to bring in sweets which may lie but a few inches distant, unless these sweets are so positioned that they are really kept warm by the bees. Giving this due consideration, it is well to remember that bottle feeders all admit of being used behind a division-board not extending quite to the floor of the hive, as explained at page 56; but they then require to be raised on two strips, to give the bees access beneath, and a few drops of syrup spilt will be at first desirable, as hinting where riches may be gathered.

The ingenious bee-keeper will at once improvise feeders suitable for standing in the position last

named, or even for use after dusk at the hive door, in the warmer weather, a tumbler filled with syrup, covered by a piece of board, and inverted, being all that is actually needed, since the bees will contrive to secure the contents by applying their tongues at the edge of the glass. The board, too, may be omitted, sliding the tumbler off the shovel, on to the hive floor, or a flat spot at the entrance, as the case may be. And, indeed, it is barely required to make a syrup, filling with sugar, adding water, and inverting immediately, answering sufficiently; and since all the food is gone by the morning, robbing is not induced. Such a supply, given nightly to a strong stock, during a failure in nectar, will keep breeding going rapidly. Four flat-headed nails, added as feet to the wooden stage, if such be used, will increase its convenience, as it can then be set down with less risk of crushing bees. In starting feeding at the hive mouth, a syrupy trail should be led from the bottle to the entrance, so that the bees may promptly begin operations, as, if the food remain until other stocks commence flying next morning, fighting and robbing are all but certain. The second evening the bees will require no invitation—they will be anxiously looking out for their attentive master.

It is the occasional practice with some, in weather permitting bees to fly without risk, and yet yielding no nectar, to feed in the open, for which the apparatus B, Fig. 100, is exceedingly suitable. This *al fresco* feeding would be a costly business to those having many bee-keeping neighbours, as all *their* stocks would understand the invitation to the banquet

as being general. The food, too, must be placed some little distance from the hives, for the commotion it occasions, if in their midst, would almost certainly lead to robbing by the excited bees, just conscious that abundance is at command close at hand. The syrup should be given very thin, and the supply must be suffered to run out towards the afternoon, or many staying too late at the feast would perish. The practice saves time, and is safe in the hands of an expert, but it is not to be generally recommended.

The specific gravity of syrup is greater than that of water, and hence the former immediately sinks as

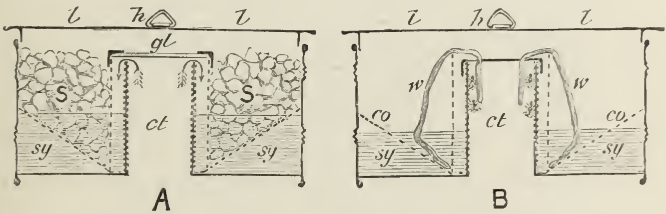


FIG. 98.—THE "AMATEUR" FEEDER IN SECTION (Scale, $\frac{1}{6}$).

A, Feeder charged—S, Sugar; *sy*, Syrup; *ct*, Central Tube, by which Bees Enter; *gl*, Cover of Glass; *h*, Handle; *l*, Lid. B, Feeder arranged for Slow Feeding—*co*, Cone of Perforated Tin; *w*, *w*, Wicks; other Letterings as before

sugar dissolves. If the sugar lie at the bottom of the vessel, the water there is soon saturated with sugar, when it is incapable of dissolving more. We all have observed, as an illustration of this, that sugar may long remain only partially melted in an unstirred cup of tea, notwithstanding the high temperature, and the extreme solubility of sugar in hot water. To complete the solution, in the absence of stirring, the denser syrup must be removed from below, as in the case of the inverted tumbler just cited, or the sugar must in

some way be kept above. Mr. Simmins has arranged this in more feeders than one. "The Amateur" (Fig. 98) may explain the rest. It consists of a circular, tin box, 9in. in diameter, and 4in. high. Through its centre rises a tube (*ct*), 2in. wide, and covered with perforated tin within and without, to give the bees foothold. The bottom is raised, so that entrance may be given from half-a-dozen frames at once if desired. Around the central tube is a movable one of perforated tin, $2\frac{3}{4}$in. in diameter, and closed above by a loose, glass lid. This tube is fixed beneath to a wide cone (*co*, B), also perforated. When the tube and attached cone are placed in the external case, the space above is filled with loaf sugar (S), and water (preferably warm, as mere solution depresses temperature) added in the proportion of half a pint to each pound, when the result is obvious. The bees, following the direction of the arrow, gain access to the formed syrup between the two tubes. This feeder presents a great surface of metal, and needs a wide separation of the bees from their cluster, and so is not intended for cool weather. When this prevails, and for slow feeding, over the inner tube (*ct*) is placed a cover, pierced for two lamp wicks (*w*, *w*), which, dipping into the syrup, hang down in the central tube, even to the very cluster, if desired, and feed by capillarity, as indicated at B. These feeders are ingenious time-savers, and a great convenience to those who have no appliances at hand for making syrup in the usual manner.

The division-board itself may, by a modification, be converted into a feeder. The form I prefer

(Fig. 99) consists of two thin boards, with an inch interspace, accommodating a tin vessel capable of holding three pints, or about 4lb., of syrup. The partition (*p*) is returned above in the partial cover (*c*), which permits of the quilt being turned back sufficiently to fill at *fh* without any bees escaping—the top bar being widened at *w*, so as to meet the next frame. The partition does not reach the bottom, an opening of $\frac{1}{8}$in. being left, through which the syrup,

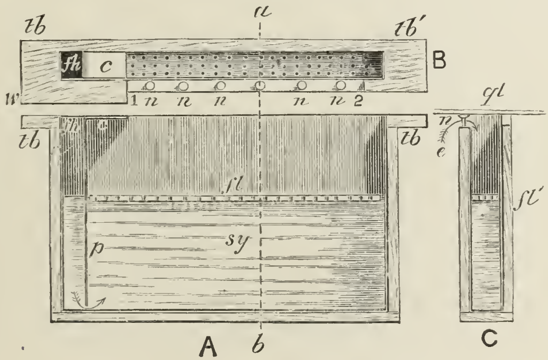


FIG. 99.—DIVISION-BOARD FEEDER (Scale, $\frac{1}{8}$).

A, Longitudinal Section, showing Interior—*fh*, Filling-Hole ; *fl*, Perforated Float ; *sy*, Syrup ; *p*, Partition. B, Top View—*n*, *n*, Nails. C, Section through line *a b*—*qt*, Quilt ; other Letterings as before.

as indicated by the arrow, passes beneath the float, which, rising, gives the bees ample standing, without sullying any of them. They drink up the food through the perforations the float carries. The top bar (*tb*) is so cut away that the tin vessel can be lifted in and out of the division-board, which acts as its case, while the bees have entrance given to them between 1 and 2, where flat-headed nails are driven at intervals into the side board, so that the quilt is supported, as shown

at *n*, C, and the passage-way (*e*) not interfered with. The advantages of this division-board feeder over others lie in the ease with which any defect in the float, the amount of syrup contained, &c., may be seen at once, while the vessel can, as before stated, be lifted out for washing and returned immediately. For dry-sugar feeding I prefer it to Mr. Simmins' pattern, (page 395), because the dry sugar can be poured in, and its condition watched while the feeder remains in the hive.

A division-board feeder somewhat like the foregoing, but without the tin vessel, and made syrup-tight either by accurate carpentry, and keeping the grain of the sides and ends horizontal, or by painting carefully within with very hot wax, can be converted into a very simple feeder by adding a thin partition $\frac{1}{4}$in. from the front, and fitting loosely, so that the bees cannot get behind it, although the syrup may pass round its edges. This is poured in behind, and the bees take it at its surface, holding on to the partition or the front while feeding. The feeder may be made of any width, and provided with any number of partitions, about $\frac{1}{4}$in. apart. Pouring the syrup over the backs of the insects as they stand feeding will save time, and rarely cause any to drown.

This principle is most usually applied where very large feeders covering, possibly, the whole top of the hive, or occupying an under storey in tiering hives, are used to give wintering stores in the shortest possible space of time. Thin partitions, which it is not quite safe to have more than $\frac{1}{2}$in. apart, stand out of the syrup. In those used above, the bees

pass up, and return by a tube-like opening, as at *ct*, Fig. 98.

Mr. Simmins' dry-sugar feeder is $1\frac{1}{2}$in. wide, and the size of a standard frame. The back and front reduce the interspace to 1in., giving room for 3lb. of a moist sugar, Porto Rico being recommended. This space must not be increased unless it be divided, or the bees will build comb in it. The front reaches to within $\frac{1}{4}$in. of the top bar, and is hinged at the lower corners on wire nails, which are driven through the sides. Or one-half only of the front is removable for filling, after which a button secures the charge. Mr. Simmins remarks that with these feeders sugar is given "in a manner that causes far greater stimulation to the bees than any plan of feeding with syrup. The trouble of making syrup is dispensed with, and the feeders are always ready for use at a moment's notice. The system is of immense value in all large apiaries, and in those at a distance from home. In many cases, no other feeding is necessary; but where any colony is likely to run short previous to April 1st, let it have sufficient syrup, in one dose, to last until that date." That this feeding stimulates completely cannot be doubted; but my use of these feeders leads me to remark that, in dry, easterly winds,* during April and May especially, the bees are lost in great numbers in flying for water. This flying is largely stopped if water be given within the hive, when a good colony will take quite a pint daily. The use of American cloth to condense moisture

* Mr. Simmins' apiary would have a more humid atmosphere than that of most inland places. My position is a dry and over-drained one.

is an insufficient expedient, and all but a total failure if the hive be covered down warmly above (by a chaff-tray, *e.g.*). If the American cloth could be kept at the temperature of the brood-nest, no moisture would be deposited upon it at all. No moisture is deposited upon a knife in a jet of steam, if the blade be as hot as the steam. The water is only gained, then, in appreciable amount, by suffering a leak of heat, which is one disadvantage to cure another. Striving to compare regulated syrup-feeding with dry sugar-feeding, as a stimulant to brood-raising, I venture to think that the former, at least in dry weather, has decidedly the advantage, although, of course, as Mr. Simmins urges, it is attended with more trouble.

Candy is a species of dry sugar which may be quite safely given to stocks appearing likely to run short of food during the winter. It is prepared thus: Add about 1 pint of boiling water to each 4lb. or 5lb.* of loaf sugar, in a saucepan. Stir carefully, and boil for a few minutes. Try if it be stiff enough by cooling a drop or two on a piece of paper, or by plunging a little of it, in a spoon, into cold water. In a few seconds it should be tough enough to draw out into threads. If not, continue to boil. When right, place the saucepan in a sink, or stand it in a vessel of cold water, stirring uninterruptedly, so as to keep the crystals (the grain) very fine, and these, between them, hold the saturated syrup. When the mass is getting into a pasty state, pour into saucers or soup-plates in

* The absolute amount can hardly be given, as much depends on the state of the fire, a slow one driving off more water, a quick one less, before the boiling point is reached. The candy must set; but short of this, the larger the quantity of water it retains the better.

which thin paper has been placed. In half an hour the cakes will have set, and may be turned out by turning the moulds over and giving them a tap on the table. If the last parts in the saucepan have cooled too much to pour, a few seconds over the fire will again set it running. The cakes are used under the quilt or chaff-tray (as at *o*, Fig. 19), the paper standing uppermost. As the sugar is eaten away, a passage is opened up between the frames over the top bar, and a cosy recess is formed for the bees.

Sugar as a substitute for honey only can be but a partial diet. *Pollen*, *bee-bread*, or *farina*, is the natural nitrogenous or tissue-forming food of the bee, and is an essential for the adult insect for its own uses. It is true that, in a condition of comparative quiescence, the worker may long exist without it—as in a travelling-box, by example; but it is demonstrable that exhausting labour cannot be continued, and brood cannot be raised, in the absence of pollen, or an equivalent. The deficiency of candy in this respect may be made good by adding to it some tissue-forming food, usually farinaceous substances, which are stirred into it, in the dry state, at the end of the boiling process. *Flour-cake* is the name then given to it, and it is an excellent provocative of brood-raising in the very early part of the season. I prefer pea-flour, and first suggested its use, because it contains about 23 per cent. of absolute tissue-forming material; whereas wheat-flour, which some recommend because it rather easily mixes with the boiling sugar, has only about 10 per cent. Pea-flour also contains much more fat and earthy matter, and so more exactly replaces pollen, which is rich in

vegetable fat, sulphur, phosphorus and potash. Whatever substance is chosen, a small handful for each pound of sugar may be stirred in. It has been supposed by some, that flour-cake is damaging to bees during winter. It is undesirable in the early winter months, unless the amount of nitrogenous matter it contains be small; but, for reasons hereafter to be stated, I believe the moderate addition of about ½oz. pea-flour to each pound of sugar to be a great advantage when candy is given as a resource during winter.

Pollen substitutes ("artificial pollen") may at certain seasons be given in the open with advantage. The balance of the economy of the hive perhaps meets with some disturbance from the fact that we deprive the bees of honey, yet, as far as possible, avoid touching their pollen; but a discriminating power on the part of the bee does much to restore the balance. The amount of this substance brought home somewhat depends upon the plant yielding the nectar (some labiate blossoms, *e.g.*, so placing it that the bees cannot collect it on their legs), but more is determined by the needs of the stock. A swarm for the first few days gathers honey almost exclusively; but as eggs begin to hatch, high-heaped pellets are constantly borne in, and deposited in the neighbourhood of the larvæ for the use of the nurses. But it is not true, as some have stated, that queenless stocks carry no pollen, and by this may be known; they invariably take a restricted amount. Sometimes, in the early spring, the lack of "bee-bread" seriously reduces the brood-producing capacity of a colony. Especially will this be true of those that have been nursed into strength by

late autumn feeding, and of stocks built up from condemned bees. Sometimes, also, in old-standing colonies, the pollen of the autumn, in the central combs, has desiccated so as to be useless, while that of the outside ones has mildewed and spoiled. One of the signs of returning activity will then be the removal of the first-mentioned, indurated masses, which the bees, with admirable perseverance, tug at and teaze until they accomplish their dislodgment. These are then dragged to the alighting-board, where, in the spring, they may be frequently observed in some numbers. Under these circumstances, farinaceous bodies exposed in bulk will often be taken by bees in considerable amount, and to their great advantage.

Artificial pollen, now largely used in many apiaries as an aid to brood-raising, we owe to the observations and suggestions of the great German bee-master, Dzierzon. He noticed very early one spring that his bees were carrying home flour, which they had stolen from a neighbouring mill. He profited by the hint, and quickly gave them this substance close at hand, with results in the highest degree satisfactory. Rye-flour and chesnut-flour—the latter at a high price—have constantly been insisted upon as especially suitable. Their chemical constituents, however, show the first ,to be unequal to wheat-flour, and greatly inferior to oatmeal, while the second is far less desirable than pea-flour.

A good plan for giving it is to place, loosely, some clean shavings in a skep, in a sunny corner, sprinkling the pea-flour thickly upon them. A wind screen, and a sheet of glass some few inches

above the skep, so as to protect from rain, will be advantages. Bees are capable of instruction: if they have been taught the value of artificial pollen, and how to handle (?) it, by previous use, they will not be slow in utilising our gift; but if not, they will probably pass it unnoticed, when they must be tempted by a bit of bruised comb containing honey, or by an old, dry piece, partially burned, to lure by its perfume, or even by a drop or two of oil of anise rubbed on the skep. Some have succeeded in inducing their bees to take artificial pollen by putting pea-flour into crocus cups, and so have palmed off the artificial for the natural; but the amount of time this performance would require must rather amuse those who know the quantity that even a single stock well at work will carry—a German authority states this at 2lb.

When a few bees, more adventurous than the rest, have got a taste, and have loaded up, the difficulty is overcome; the rest will follow, and soon a deep hum will be heard from hundreds of busy gatherers. They do not object to coat themselves completely, diving in the head, and getting a dusting on the under side of the thorax when they rise on the wing, in order, by the action of the legs, to gather up and duly stow away the supply, which is made adhesive by addition of saliva from the extended tongue constantly passed between the front feet. Now a second dusting adds to the amount before secured, and which is already noticeable as small pellets standing upon the so-called pollen-baskets (page 131, Vol. I.). Another dive or two, and they, fully

loaded, fly off to their hive, as white and as merry as the miller and his men. The pea-flour is packed so smoothly and closely upon the legs, that it glistens with a polish, and is semi-transparent. It is filled into the cells of the brood-nest precisely like the anther dust of flowers. In fine, mild weather, the bees will labour at this work with great industry, preferring the meal to the old pollen. They, in consequence, breed early, and rapidly recruit their numbers. When the opening blossoms furnish a natural supply, the substitute is neglected. Yet so eagerly is the latter taken in some cases, that, where the supply is granted without stint and without interruption, an excess, useless, if not even harmful, may be carried. It is wise, as natural sources become available, to discontinue our bounty the more quickly, to compel the bees to repair to the blossoms.

Artificial pollen, given as now described, necessitates the bees leaving their hive, and, in some springs, colonies, possibly needy, are kept within by stress of weather. Some years since, reflecting that, when natural pollen is stored, it is frequently covered with honey, and then sealed with wax, I concluded that, possibly, the artificial pollen mixed with honey, or its food equivalent, might be placed at once in the cells, and so save the bees the need of the exposure and labour involved in gathering and storing it. I therefore mixed pea-flour with syrup into a paste, and, removing a comb from a colony distressed for lack of pollen, applied the paste with a flat knife, as boys at school sometimes apply butter to bread, "to fill up the holes." About 3oz. of pea-flour were put into

the cells, and the comb returned. Two hours later the bees had sucked out the excess of syrup, and had packed the pea-flour down in the most beautifully regular manner, as though it had been pollen gathered in the natural way. Thus, what with much labour, and, probably, much loss, could only have been accomplished by the efforts of hundreds of bees, had been done, through my help, by a few, with comparatively no exhaustion, and actually no exposure. Next day, the greater part of this pea-flour had been consumed, while the dry, starved appearance of the brood, well known to those who have over-swarmed artificially (page 285), had passed away. Giving doses of pollen as needed worked the stock into prosperity in most adverse external circumstances.

Experimenting further, on the 8th of October, 1878, when scarcely a speck of natural pollen was obtainable, and bad weather prevented outdoor gathering, I put $4\frac{3}{4}$lb. of bees, taken from eight skeps, into an empty hive, fed syrup freely, and examined all on the 11th. Comb had progressed well, and eggs were laid. As I removed a comb, and pasted my pea-flour mixture into it, I felt some compunction in marring its spotless purity. Forty-eight hours later, almost the whole of it (3oz.) had been consumed. There were yet no hatched eggs that I could find. The bees, under the labour of comb-building, needed the nitrogenous food which the microscope showed in abundance in their stomachs. The bees had made comb on sugar only, but were doubtless growing in some sort emaciated under the process, and the pea-flour supplied the place of the pollen they would have consumed whilst gather-

ing their sweets, had this been done in the natural manner. What an absolute refutation this to those who assert that bees never eat pollen—a guess utterly at variance with all scientific theories! The hive, late as was the season, went along splendidly, raising great breadths of brood, and receiving its pea-flour as occasion demanded. Good as were the results, and important as is the teaching, a caution is needed. Pea-flour thus given must be mixed with sugar carefully inverted—that is, changed into dextrose and levulose by boiling with acid—or honey must be employed; and even then, that which is not quickly consumed is so dried of its sugary matters that it becomes too hard for use by the nurses, and has to be removed at considerable labour to the bees. In the few cases in which it would pay for adoption, the plan, judiciously carried out, is doubtless most serviceable.

We have not exhausted the *menu* of Mistress Apis, for both the dairy and the hen-house have been made to contribute nitrogenous aliment for her support under the trying duties of wet nurse to a numerous offspring. Herr Hilbert was the first to use milk, and subsequently egg, concentrated nitrogenous foods, both, but especially the latter, largely yielding the very material for building up animal tissue; for, during incubation, the albumen of the egg is converted into every part of the body of the chick. He recommends that they be given in early spring, and discontinued when natural pollen becomes abundant. The milk he boils with a considerable amount of sugar, and feeds in a tray-feeder beneath the frames. I have given it in a simple bottle, and have used about 1 pint

of milk to 1lb. of sugar. The bees take it greedily, and raise brood in consequence very rapidly; but they store it in their cells, so that decomposition subsequently sets in, and they then refuse to remove it—at least, this has been my experience with every trial, and at present I have a stock suffering from this very cause. Baron von Berlepsch found the same. Care, moreover, is required, or the feeding-vessels get badly fouled, and the milk sours immediately. The souring, however, does not hinder the bees in appropriating it.

Herr Hilbert claims to have had no difficulties, and to have succeeded in getting, by means of his plans, overwhelming populations. The egg diet he prefers to the milk. The white and yolk are well beaten up, and mixed with honey or syrup—2lb. honey or syrup to 1lb. of egg substance. It is given beneath the cluster, when the bees only take so much of it as they can use at the time for the preparation of brood-food; but it has the great disadvantage of driving out the bees to search for water, of which the milk diet contains sufficient. If any stock, having already accepted egg food, refuse it, no further supply is offered them for a week; but the mixture is taken to a more needy lot. The Hilbert system is too messy, and involves too much risk, to make it generally acceptable, although at times it might be peculiarly useful, as with the condemned bees previously referred to, for its stimulating influence is, possibly, unequalled.

Water, the prime necessity of all life—for without it not even an animal or a vegetable cell can live—is at least as needful to bees as food. Bee-hunters

are quite familiar with the fact that no colonies of wild bees will be found in a district where water is not readily obtainable, "bee-trees" being almost always situated at no great distance from a stream. Honey, as drawn from blossoms, is extremely limpid, and when first stored will flow from the cells with a freeness hardly less than that of water itself. If, in the height of the honey season, a comb in course of filling be taken from a frame-hive, put on its side, or turned upside down, and gently jerked, the newly-gathered nectar will at once be displaced; whilst that of earlier collection, although unsealed, as it may be, will require the extractor to remove it. The latter has lost its excess of moisture, and is approaching the condition for sealing. That ordinary evaporation has much to do with this thickening is all but certain; but that it is the sole cause, as generally stated, is extremely doubtful, the bees, in moving their watery honey from cell to cell, seeming to possess the power of extracting from it some of its water; and frequently, when bees are rapidly gathering, they make discharges which, by their character, clearly come from their Malpighian tubes, the equivalent of the kidneys of the higher animals (see page 286, Vol. I.).

While honey is coming in, it provides the requisite water for forming the diet of the larvæ; and hence, bees then are quite independent of our assistance in this direction. But in early spring, when breeding is progressing, and the hive contains no honey but old store, the poor inmates often suffer the direst distress for lack of water. They may at such times be found flying in search of it, even when the temperature is so

low as to make the death of not a few certain. One of the signs of water dearth is the collection of particles of candied honey on the floor-board. The nurses uncap the cells in succession, and extract from each the most liquid portions, dropping, from time to time, the solidified particles upon the floor beneath. When nothing remains but that which is candied, they, according to a German experimenter, attack the unsealed larvæ, and devour the eggs, if any are still unhatched. I have never seen this extreme condition, but in the

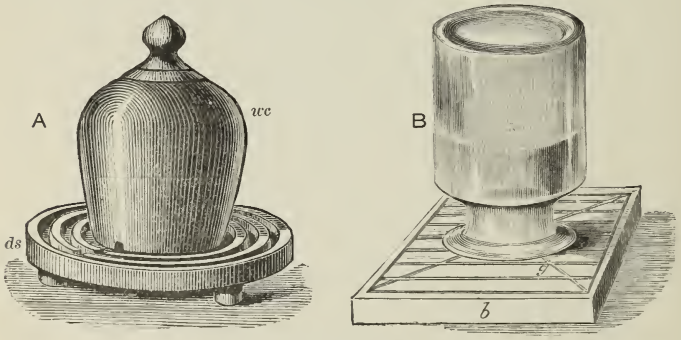


FIG. 100.—BEE-FOUNTAINS.

A, Earthenware Fountain—*wc*, Water-chamber; *ds*, Drinking-stage. B, Bottle Fountain, or Open-air Feeder—*b*, Board; *g*, Grooves.

absence of liquid honey such results are to be anticipated. American cloth, placed over the tops of the frames, has been previously referred to, its service depending upon its reduction of evaporation, by stopping all upward ventilation, as much as upon the water which actually condenses upon it. The most effectual remedy, in weather which forbids the bees flying, is to give a comb the cells of which have been filled, by a syringe, with very thin, warm syrup,

or the division board or bottle feeder filled with the same.

The rapid evaporation in the hot season incident to the continuous inflow of fresh air then needed, obliges the bees to be at work early in the morning gathering the dew with which to thin the food required by the multitudinous grubs. The wise bee-master would not leave his bees to search out their own watering-place, or they may learn to depend upon some intermittent supply, and when that fails many will be lost, both at home and abroad. For small apiaries, the earthenware fountain (A, Fig. 100) will be suitable. The water-chamber (*wc*) is inverted and filled, when the drinking-stage is placed upon it, and both are turned over together. The water fills the grooves, from which the bees may drink in safety. The bottle fountain (B) is similarly managed. The stage consists of a thick board, about a foot square, into which grooves are cut, $\frac{1}{4}$in. deep and wide; these may be placed as near to each other as the bee-keeper desires. Either of these appliances is available for syrup, for open-air feeding, as indicated at page 390.

For larger apiaries, tanks provided with floats, or having gently sloping sides, would be desirable, unless some natural supply render the arrangement unnecessary. Mr. William Raitt has, in a sheltered spot, a shallow tank, containing spent tea leaves, to which water is from time to time added. I have never tried it, but the name is a sufficient recommendation.

Two warnings seem desirable. First: Do not provide the bees with water and, when they have learnt

to trust to it, forget to continue it; better far never give any, or your well will be dry just when water everywhere else is scarce. Give none, and the clever creatures will rub along without your help, perhaps not so well as though you gave it; but make them dependent, and then desert them, and they will be, probably, reduced to such straits as will make both bees and master suffer. Second: Carefully avoid leaving feeding-bottles, &c., so as to collect rain, or your bees in their searches will fall in, as into a trap, and many a score will be destroyed.

Packing bees for long journeys, especially to warm climates, depends more than anything else upon giving sufficient water. With it, most trying temperatures can be sustained. I have on several occasions sent full colonies of bees to India, and the main precaution has been to give, with sufficient ventilation (and this may be excessive—see page 262), an unfailing supply of water. A pouch was arranged at the back of the travelling hive, just beneath a 2in. hole, open to the bees, and covered with perforated zinc. This pouch was daily filled with water, into which was placed a large sponge, with its side lying against the zinc window. The bees were carried in one of the ship's boats, on the port side, to screen them as much as possible from the sun, and were shaded by a tarpaulin. On one occasion only, when watering was neglected, did they succumb.

Even during the icy grip of winter, the instincts of bees direct them to make preparation for the prospective gathering of Nature's bounty, by starting brood-raising, and commonly as early as January, in fairly strong

and well-conditioned stocks, the most extreme weather will not prevent eggs being laid. Although these wondrous little political economists thus hazard a cautious expenditure, which may become a profit, through a harvest of which as yet there is no prophesy, they will only breed rapidly while they feel themselves already in possession of an income justifying the great consumption of store extensive breeding entails. These principles need remembrance in studying the important question of *spring stimulation*, respecting which there is great difference of opinion; yet the actual difference is less than the apparent, since locality, flora, climate, object (bees or honey), amount of time at disposal, &c., account for much of the divergence. In Britain the honey season is, even in the most favoured districts, comparatively short, and the main point is to secure immense populations in our hives, which shall reach their maximum at the opening of the first great honey-flow.

Stocks in good hands will, as a rule, demand no attention during the winter months, which should be passed by the bees without external disturbance of any kind; but with the opening of spring, with the first fine days in March, an examination, in which the bees are as little aroused as possible, may be made, to ascertain their condition and the amount of stores they still possess. The chaff-tray (page 61), which I have so many years advocated, and which many are now beginning to use, being lifted, or the carpeting raised, we look for food, and, if this be apparently needed, provide a cake of candy, putting over it American cloth—if it be our practice to use it; or we may give a large

bottle of syrup, fed rapidly. Colonies in great want should, if possible, be supplied with a warm comb of store from some stock possessing enough and to spare. It is, generally speaking, unwise at this early date to hunt up the queen, as the involved exposure and disturbance are undesirable; but any stock discovered to be queenless should be united to another, those having unimpregnated, or drone-breeding, queens being treated in the same manner. Should the bees, from any cause, be greatly reduced in numbers, outside, useless combs should be put beyond the tight-fitting division-board, and the lessened company again made as snug as possible.

All are agreed that the early part of March is too soon to stimulate; yet, if our district be in the South, and such that fruit-blossom is our sheet-anchor for honey, we must start thus early in order to be in time for pears and apples: but bees will not now answer to the helm as in a month later, and no precautions will prevent their flying from the hive on bootless excursions, during which numbers meet their fate. Many authorities say that early stimulation will lead to spring dwindling—*i.e.*, a condition of things in which the old bees die off more quickly than new ones are produced, and the colonies dwindle, until often they become useless. There is, undoubtedly, a *diseased* condition—of which more hereafter—which leads to spring dwindling; but, apart from this, a prolonged experience justifies me in saying that early stimulation in the South of England does not necessarily develop any indications of dwindling. If it should do so, the cause lies in such poor protection during

the winter that the bees have been overtaxed in maintaining their temperature, and are in the spring already infirm, instead of ready for the duty of raising a new population.

In the South by the beginning of April, in the North, according to Mr. Raitt,* some weeks later —the period to some extent determined by the first abundant gathering of pollen—spring stimulation may most fittingly be commenced; for it is now needful that the bees raise brood to their utmost capacity. To this end the colony must be enabled to keep up a considerable temperature, and removing the outside combs, so that the bees are somewhat crowded between the dummies, is most important. This removal of combs decreases their resources, but will not discourage brood-raising if we begin to feed; and it is not really necessary, and at first not desirable, to give new material, as our object is not an accumulation of store, but a densely-filled brood-nest. I have already hinted that bees do not so much arrange their household expenses according to that which they have laid by, as according to income; so that they are greatly stimulated by simply uncapping their store, when their removal of the honey from each opened cell, in order that they may repair the slight damage which our uncapping has occasioned, will affect them much as though an equal amount of food had been given them. Instead of uncapping with a knife, as is usual, I employ a wire hairbrush, with which I strike the comb a few times, making punctures in the cell cappings; this causes

* *The Bee-keeper's Record*, Vol. V., page 41.

no mess, and is less troublesome, while the bees utilise the contained honey if it be placed near to brood, and free the cells, at the same time, for the use of the queen.

Mr. Simmins, in order to induce brood-production, would put a dry-sugar feeder, holding 3lb., on each side of the brood-nest, replenishing as needed; while those who use syrup would adopt some of the devices for regulating the rate of consumption. With dry sugar many bees are constantly struggling to load up, by licking sugar crystals, and a regular, but moderate, influx of store is the result; while with the Raynor feeder, *e.g.*, a similar effect is produced by means already explained. The large bottle of syrup directed to be given to those found needy at the first examination in March is to be "fed rapidly," because it is desired that this shall not stimulate to brood-raising, but increase store. Syrup thus given is hastily carried down by the bees, and deposited in the nearest place (the brood-nest), so that the unburthened labourer may return to the temporary "land of plenty" for a fresh load. The queen, instead of being incited to more rapid ovipositing, as a result of the incoming supplies, simply has the cells, which otherwise would have remained open for her service, closed against her. Before any permanent animation is produced, the supply is gone, and all lapses into its previous condition; but with continuous slow feeding, where only two or three bees can fill their honey-sacs at one time, how different is the effect! Food comes in slowly it is true, but the supply is constant —day by day the store increases, and the thrifty

little insects come at last to trust in what appears a perennial spring. The natural result is a wider deposition of eggs, and the grubs, in due course, consume the sugar supplied, so that we positively exchange our syrup for bees. The increasing colony will require to have the combs, of which it has been dispossessed, restored to it; but on no account should any be given until they are actually needed.

Circumstances of very varied kinds will influence the details of spring treatment considerably; *e.g.*, if our aim be clover honey, which begins to become abundant rather later than the middle of June, we *should* be able, if we intend to prevent swarming, to secure immense colonies for supering by starting stimulation at the beginning of May, when, in fair weather, but little feeding would be required, our results being achieved by the manipulation of the brood-nest described in the next paragraph; but by stimulating a month earlier we may, in most seasons, have both stock and swarm ready for the same crop as honey-gathering colonies. Six weeks is the time usually specified as being sufficient for building up to giant strength. This *is* sufficient if we start with those in good condition, having prolific queens; but with weak lots, unless these are aided by combs of brood, a much longer period is required.

The form of the brood-nest is approximately globular, for reasons given at pages 31 and 35, and indicated at A, Fig. 101; and as the bees increase, the nest is enlarged on all sides, so that the nurses may be condensed, and the vital heat more easily retained by the peripheral bees, aided by the out-

lying combs. If, now, comb 5 be removed from the outside to the centre of the nest, as at B, it will have the very warmest and best position for the raising of brood, of which at present it contains but a small patch, on one side. The store it carries will, therefore, be displaced (used mostly) whether it be sealed or not, for bees will not allow food to remain sealed in their brood-nest. The cells are now cleaned until their bases will glisten in the light, and so afford the queen accommodation for a great number of eggs. By our interference the whole contour of the nest is

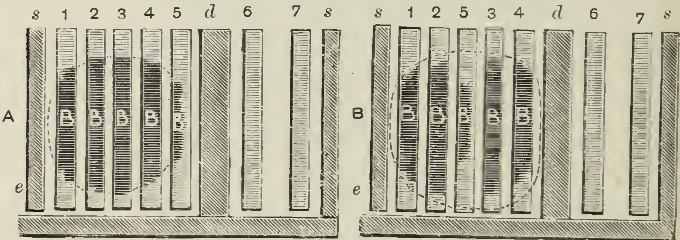


FIG. 101.—BROOD SPREADING.
A, Combs in Normal Position—*s*, *s*, Hive Sides; *d*, Division-board; *e*, Entrance. B—Combs of Brood Spread; Letterings as before.

disarranged, and the cause operating in filling comb 5 will restore promptly the globular form, while the nest will be enlarged in all directions. If the bees previously were doing their best, they are now overtaxed, as they have a larger space to cover, and more heat individually to produce; and, should a cold snap occur, they possibly will be forced to condense, and leave the large mass of brood on the outside of comb 4 to chill.

Spreading the brood is the name given to this systematic disturbance of the brood-nest; and although

it is, undoubtedly, capable of accomplishing great things, it may, if prematurely or excessively practised, cause nothing but loss. The learner should exercise the greatest caution, and make haste slowly, and, instead of taking an empty frame and inserting it in the centre of the brood-nest, he should endeavour to get the frames already in the hive filled with brood. If the nest is established towards the end of the combs, turning the alternate ones will "spread" sufficiently for a week at least. If, at the next examination, the bees have responded to our invitation to enlarge their borders, we must not conclude that they are able to bear a still greater increase. The practised eye will determine at once, but the novice must ask whether young bees are hatching out in any numbers, for our interference, for three weeks after spreading the brood has been commenced, will rather tend to *diminish* the working population, by increasing the death-rate through forced marches. Brood and store (as much of the former and as little of the latter as possible) filling the combs, new ones may be introduced, and that as frequently as the bees are able to nurture the grubs the deposited eggs produce; for it is quite possible, by this plan, to get eggs laid which are never converted into bees, and, if we are going at so high a pace that the bees cannot keep up with us, we shall find that all eggs, and possibly young larvæ, turned to the outside of the nest, disappear. It is, of course, understood that food is provided as may be required while the forcing process is in operation. All working as we desire—and neither with bees nor men does this always

happen—at the end of the theoretical six weeks we find our hives crowded, every frame—ten, or at the most eleven, standards—containing much brood, and the remaining space occupied with store, and a honey-flow just opening. We now turn the current of the colony in the direction of honey-gathering, to which matter the next chapter is devoted.

Autumn feeding in preparation for winter, where our system renders such necessary, will require attention almost immediately after the last sections are removed, or the work of the extractor completed. Modern management so entirely separates the brood-chamber from the honey department, that the bees are often deprived of, practically, *all* their stores; and, paradoxical as it may appear, the most populous colonies, and those which have given the largest supers, are usually just the ones which most urgently require aid. It must be borne in mind, that when a stock is storing in a super, the stimulus of prosperity, and the apparent riches of the community, act upon the queen through the workers, and result in continued and energetic ovipositing, so that often almost the whole body of the hive is one large nursery. But the poor bees have, for our advantage, to find, as sometimes, perhaps, their masters have done, that "riches take unto themselves wings and fly away;" and, just when supplies suddenly fail, by the reaping machine, perhaps, laying in a few short hours their "El Dorado," they are left with the drain of an immense family, without the independency they had struggled to accumulate.

Such stocks should now receive a large dose of syrup, fed rapidly, to prevent them being discouraged,

and then, if the fields are yielding nothing, Mr. Simmins' dry-sugar feeders may be used, permitting them to continue breeding, but with constantly decreasing energy, until the latter part of September, when their stores, if necessary, should be quickly completed by a dose of syrup, which the bees will at this date seal over almost completely. Delay in this matter* will oblige them to go into winter quarters to their disadvantage, with much of their store unsealed; while the surplus combs, presently to be removed, will be in poor condition for keeping till the following spring, to be then returned as explained under "Spring Stimulation." Of course, we are speaking of stocks that have been totally deprived.

The amount of store required by a colony much depends upon the manner of wintering—the less adequate the protection, and the more faulty the method, the greater the amount of food required. It is false economy to leave a stock too poor, and those with more than a sufficiency are not only safer, but usually come out stronger than others; 20lb., or about four standard frames fully stored, is generally mentioned as the correct amount, and strong stocks should not have less. Yet the consumption, apart from the production of brood, from the middle of October to the beginning of March, need not, in average seasons, be more than one-fourth of the weight given.

Some bee-keepers insist upon the necessity of keeping up breeding with some briskness until the end of

* The difficulty of successful wintering with unsealed stores has been much exaggerated. With proper management, the question of sealing is of secondary importance.

September or middle of October, so that young, energetic bees may pass into the winter with all their life before them, and carry on the work of the following spring until a new generation has arisen to supply their places, spring dwindling being, I am sure erroneously, ascribed to the age of the bees at the beginning of the winter season. I have, in years gone by, advocated this position, but have long seen that the effort of raising late brood is often as destructive as it is constructive; and sometimes *more* power is taken out of the old lives than is put into the new, while the excitement late feeding and breeding maintain sends bees abroad to chill and die in such numbers that their loss tells seriously upon the ease with which temperature can be kept up during cold spells. But I am not now running to the opposite extreme, and saying that supers should be removed, and breeding closed with unnatural abruptness. I merely deprecate an effort to secure young bees when climatic conditions seem to forbid.

Robbing is an occasional trouble to the careful bee-keeper, but it is a very plague to the untidy. When nectar is distilling bountifully in the blossoms, bees leave syrup, or even honey, untouched, and then great liberties may be taken. Mr. Broughton Carr,* *e.g.*, narrates that, in removing his supers in July, he merely stood them against the hives from which they had been lifted, when the proper owners left them without a sign of "robbing," simply crawling back into their home. The abundance of the honey

* *The Bee-keeper's Record*, Vol. IV., page 139.

flow was proved by the behaviour of the bees, for in a time of scarcity, with a temperature high enough for bees to fly, such an experiment would be the reverse of gratifying. Blossoms failing, the busy creatures try every cranny that smells of food to secure sweets, not for themselves—so let us not blame them overmuch—but for their progeny and their homes. A food-bottle exposed, if with only a trace of syrup, or a few drops of honey spilt, will now, possibly, work mischief, for a crowd soon gathers, each one eager to secure a load; and the consequent fighting over the booty, with angry, high-pitched notes, is frequently the prelude of further trouble. The demoralised bees, having licked up the repast provided by carelessness or inadvertency, now cast about for riches in the bulk, which may be had for the taking; and soon dodging inquirers, tempted by the perfume, will be seeking at neighbouring doors to pass the guards. Well-conditioned stocks give the would-be robbers but little chance; but the weak, the queenless, and broodless, are less vigilant and determined, and, ere long, possibly, an organised attack has been commenced, and great excitement is accompanied by continual tussles, in which twos and threes roll over the alighting-board to the ground, upon which several dead and dying may be seen. This may last even for a few days; but usually "the combat deepens" quickly, and, amidst an uproar which cannot now be easily quelled, the doomed stock is robbed out, the vanquished sometimes making common cause with their assailants, and assisting to carry off all that is removable to the robbers' home, which they henceforward adopt.

When robbing has been once fairly started, it is exceedingly likely to spread, for with bees, as with men, a lapse into dishonest courses is not often followed by a return to virtue; while bad example in the few tends to demoralise the many. The trouble must be dealt with, for, if the robbing propensity be thoroughly aroused, the peaceful hum of the apiary may soon be exchanged for a very pandemonium of strife and destruction; and, should one colony only, suffer, the mauraders, emboldened by success, will be eagerly watching for another chance, putting every stock on the defensive, and begetting general ill-temper, which may make the bees a nuisance by the frequency with which the sting is brought into requisition.

The upsetting of syrup, the accidental exposure of honey, keeping stocks long open in times of scarcity, queenless colonies, excessive use of smoke, careless harvesting at the close of a honey flow, and the nursing of weaklings, are the main provocatives of robbing. The causes may be avoided or reduced, but with every caution it will at times occur. If noticed early, while the attacked hive is still earnest in its defence, it is usually not difficult to repress it; reducing the entrance to $\frac{1}{4}$in., and repeatedly sponging the hive with common carbolic acid stirred in water, or dredging carbolic acid powder over the combatants on the alighting-board, or, better, hanging over the front, or porch, a cloth sprinkled with carbolic acid or creasote, is often sufficient. The defenders, being able to keep back a host at the narrow pass, gain courage, while the invaders are repulsed by the nauseous carbolic like Tartars before a Chinese stink-pot. But it must not

be forgotten that a repulse is not utter defeat, and even for days after, if our precautions are relaxed, the attack is likely to be renewed.

Broodless or queenless stocks may, meanwhile, have their lack supplied, the addition of a comb or two of brood, in all conditions, having an immediate and almost magical effect in restoring courage to the disheartened; while they should be put into the best condition for defence by having their hive contracted as much as possible. In bad cases, it will be needful to close the hive altogether, giving ventilation, and transferring it to a cellar or dark room till the fourth evening, when it should be put upon its own or a new stand, its mouth slightly opened, and protected, if practicable, as advised on the succeeding page. As honey is scarce, no loss is involved, the worried insects recover in their enforced idleness, and the robbers shut in with the rest will probably remain and assist the defenders.

Another admirable plan is to throw over the hive a sheet, weighting the latter to the ground by brick or board, removing it at dusk, to give the proper inhabitants entrance. After dark, the stock is carried to another part of the apiary. The manipulating-tent (Fig. 103) may be conveniently employed in lieu of the sheet. The bees, as a result of their fright and annoyance, mark their new position, and very little loss is occasioned. It might appear wiser to keep the sheet or the tent for a day over the stock in its new position; but this would but make it again a mark for the enemy. Leaving the bee-tent in place after the removal of the stock does good, by deceiving the assailants.

The usual narrowing of the hive mouth, although very helpful to an attacked colony, is not by any means uniformly sufficient, even at the very opening of the assault. Robbers that have gained confidence by success, present themselves with so much assurance, that they often slide past the guards, and get into the wider opening behind the doors, before they are known to be intruders. This happening continually, will allow an intimidated hive, *after* the narrowing of its mouth, to still suffer from the attack, which may slowly, yet surely, work its ruin in spite of the precaution taken. If, however, the mouth be not only narrowed, but have

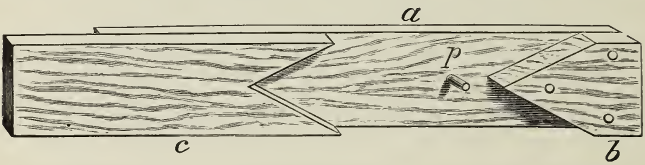


FIG. 102.—CHESHIRE ANTI-ROBBING ENTRANCE, seen from beneath (Scale, $\frac{1}{8}$).—*a* and *b*, Fixed Slips; *c*, Sliding Piece; *p*, Pin or Stop.

the form of a tunnel given to it—as by two pieces of tile set nearly together, with a third over them—the would-be thieves are placed at a tremendous disadvantage; they have to pass guard after guard, and, the moment they are challenged by one, others are at hand to do battle, or commence the work of ejectment. The combatants fill the aperture in the tube-like opening, and the skirmish, which, by its excitement, gives, in ordinary arrangements, opportunity to sneaking watchers to slip in, bars all ingress. The defenders gain courage, and the marauders, finding it all fight and no booty, seek some new field for their energies; and, to prevent these being possibly turned

against some other colony, send the disturbers home apace, with a good wetting from the garden syringe.

My very simple device, which increases the helpfulness of the tunnel, and is also of service in winter, as noticed under its proper head, is seen at Fig. 102, and as applied to the hive, at Fig. 17. It consists of three slips about 3in. wide; the lower two (*b* and *c*) are made by dividing one piece rather more than the extreme length of the hive mouth, and ½in. or ⅝in. thick. The cut takes the form of an acute zigzag. The shorter piece (*b*) is nailed to *a*; the loose piece (*c*), sliding backwards beneath *a*, gives, without reduction, the size of the opening to the hive as all three stand together on the alighting-board. The opening is, however, altered in a moment to suit season and size of stock, and has this great advantage, that when robbing begins, and it is needful to make the entrance very narrow, it is still the one known to the proper inhabitants, to whom it, in consequence, does not add the disadvantage of a bewilderment at the very moment home has to be defended against an enemy. The sharp bend now makes the attack more difficult; and if a pin (*p*) be placed on the under side of *a*, near the point of *b*, the danger of narrowing the tunnel so as to *prevent* bees passing will be avoided. It is generally wise, when it is necessary to carry the contraction of the mouth to extremes, to place perforated zinc over the feedhole, or in some way to give subsidiary ventilation; and after a battle an examination should be made at night, lest the bees, in their hurry to carry out their dead, should have blocked the narrow outlet.

Accidents will happen in the best-regulated apiaries;

and should syrup be spilt, or honey dropped on the ground, a sprinkling of carbolic powder will prevent a bee touching it, and so save all excitement, with its consequent danger.

In the fall of the year, it is often difficult to perform even necessary operations, because no sooner is a hive opened than robbers are on hand; bees quickly learning to watch the apiarian about, knowing that where he is, there, probably, plunder is at command. He has been, perhaps, tormented, and hurriedly closes a stock, hoping, on the other side of the apiary, to be able to change a queen, it may be; but the wily plagues follow him, and start in lively style the moment the frames are bared; but a resource remains, which may often be of service. I have already hinted (pages 234, 347) that much may be done by lamplight, and that then bees do not fly. To those who have never tried, it would appear almost incredible that at night queens may be found and displaced, bees divided and united, and even honey extracted, with fewer stings than would be received in the daytime if robbers are harassing. For this work a hurricane lamp, which no wind troubles, or a bull's-eye, which allows us to stand in the dark while the combs and the hive top are illuminated, are much to be preferred. The smoker would, of course, be used, as in ordinary manipulation. It may be mentioned here that in sharp weather, or, indeed, at any season (see pages 297 and 342), almost any operation may be performed by removing the bees to a warm room, and allowing only so much artificial light as may be actually necessary.

The ubiquitous robber can also be nonplussed in

another way. We simply need a small and light tent, covering hive, bees, and operator. Mr. Root advertises one composed of net, which can be folded like a huge umbrella; but a structure somewhat more stable would give greater satisfaction, and a tent 6ft. high, 2½ft. wide, 3½ft. long,* made to fold flat, need not weigh more, complete, than 35lb. If the bee-keeper can dispense with the folding, the construction is so simple as to need no description beyond what can be gathered

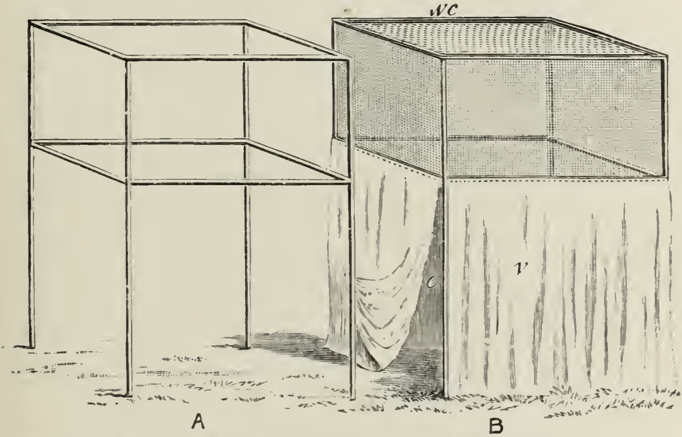


FIG. 103.—MANIPULATING-TENT, TO PREVENT ROBBING.
A, Wooden Frame. B, Tent complete—*wc*, Wire-cloth; *v*, Vallance; *e*, Entrance.

by Fig. 103. The frame (A) is made of light pine, 1¼in. square in section, and destitute of knots. The upper part is covered with fine wire-cloth, ⅛in. mesh, or with strong, black, mosquito net. If the latter, diagonal struts on the frame are needed. The lower part may be either net or calico, the objection to the latter

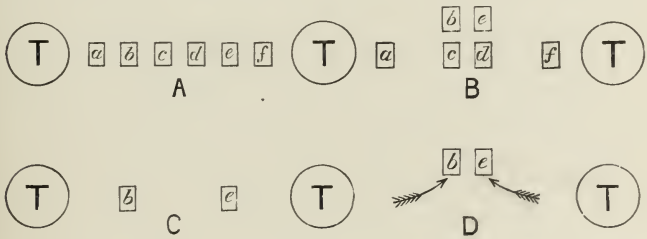
* 3ft. by 4ft. will cover, at a pinch, two hives, and would be more commodious.

being the hold it takes of the wind. The vallance may be either free to roll up, or be nailed down the legs, one angle being left loose, to give the operator entrance. A fastening will be only required when the tent is used for a considerable time over one stock. In the hem of the calico it is desirable to inclose a light iron chain, which will fit down to any inequalities, and so prevent bees entering beneath. Not only, with this appliance, can hives be opened and examined in comfort under any circumstances, but any colony may be shut in out of the way by simply placing the tent over it (see page 421).

Moving stocks and re-arranging the apiary are never quite so easily managed as after a long, cold spell, making the bees enforced prisoners for weeks in succession. Whenever, then, the temperature rises sufficiently (from 50° to 55°) to enable them to have a winter dance and discharge their fæces, they appear to note their position anew, and usually, without trouble, enter the hive, wherever it may have been placed; but stocks vary a good deal in this particular. Except under the circumstances mentioned, bees do not ordinarily note their surroundings after these have been once learned, and then the removal of their hive even a few feet will utterly baffle them. They fly helplessly round at their return, and, worn down, settle about the old spot to perish. Should other hives stand near by, they make an attempt at entrance, often to pay the death penalty; while if very many pass the guards unchallenged, they are likely to ball the queen, and possibly destroy her.

Hives may, of course, be moved long distances (not

less than a mile), during the working season, with no (or only inappreciable) loss, because the bees are placed on new ground, and so note their locality at their first flight. After remaining three or four weeks, they can be returned to the desired spot in the old apiary, because population will have changed and memory will have faded. Or they may be moved small distances each day on which the bees have freely flown, and thus, by degrees, be transferred to the position required. The interval over which any hive may safely be carried depends considerably upon surroundings. By example, if ten or twenty hives stood



near each other in an otherwise vacant field, the hives bodily would form the landmark directing the weary foragers home; and in this case, the whole apiary might be carried twenty yards or more without damage, if the mutual positions of the several stocks were carefully preserved: for first the hives would be found, as a whole, by the bees, and then the special entrance would be indicated by its relative situation. But if the hives had previously been gathered beneath the shade of a conspicuous tree, the loss resulting from a change of even 5ft. or 6ft. might be serious. To

make this clear, suppose six stocks (*a*, *b*, *c*, *d*, *e*, *f*) to stand between two small trees (T, T), as at A. The removal of *b* and *e* to the positions at B would cause disaster, as the whole flying population of *b* would attempt to enter *a* or *c*, while that of *e* would join *d* or *f*; but if *b* and *e* be the only stocks (as at C), an identical alteration in station would cause no difficulty, unless the space moved over should exceed 5ft. or 6ft., as the returning bees would, without possibility of entering the wrong hive in mistake, fly to the entrances as indicated by the arrows at D.

Bees may be made to notice that they are on a new stand, and to adhere to it, by sundry devices, of which the best, perhaps, are given at page 273, principle 6. Following on the same line, we may frequently succeed by moving, and then immediately shaking them all in front of the hive, letting them run in the manner of a natural swarm. Some will fly back to enter the decoy hive, containing a comb placed to receive them. These should, when collected in the evening, be thrown down at the station of our choice, when their thorough fright will often cause them to stay. The repetition of the process, in any case, will reduce the loss to a minimum.

The packing of bees for transit has already received some attention, and it is only needful here to enforce the necessity of skeps conveying swarms being inverted. A skep *in situ*, however propped, is extremely likely to compass the death of a large swarm, for reasons given at page 136. Stocks with new combs are quite unsuited to travelling. Skeps containing those of some toughness should be closed by cheese-

cloth, and inverted in all but chilly weather. Combs always travel best in the inverted position, because the heavy honey then rests immediately upon the base, and tends to hold the comb, instead of drawing it from its attachments; but in cold times, bees would get too much chilled in inverted hives. In cold weather, both frame hives and skeps can be carried in the natural position, the mouths being closed with perforated zinc. Frame hives with strong colonies, in warm weather, should be covered by cheese-cloth, or perforated zinc, above and beneath, and the frames should be held in position by nailing two strips, which run across the line of the ears. The nails need be only partly driven home, so that they may be easily drawn. With sufficient fixing they permit to the frames a certain amount of swing, which relieves the energy of an accidental blow. Frames too firmly fixed are much more likely to arrive with combs broken down; on this account I do not think sticks between the frame sides to preserve the interspace desirable. For cart carriage, a smooth bedding of straw is of great service.

Should it be required to send off several colonies when many of their bees are abroad in the fields, the returning foragers may be saved by giving them a nucleus in the centre of the space cleared; and, in the same manner, when bees must be moved small distances at awkward times, a little ingenuity will permit the last moved, and preferably queenless, colony, to gather up the wanderers; or, by the aid of the latter, a nucleus may be started.

In re-arranging the apiary, our notions of symmetry

must be made to bend to the habits and instincts of the creature upon which both pleasure and profit depend, or failure may dog our steps, however painstaking these may be. I well remember visiting the apiary of a titled owner, which, with the advantage of modern appliances, and the attention of persons of culture, failed to produce results at all equal to those obtained by the aforesaid gentleman's tenantry, whose rude methods he was anxious to displace. The proprietor, a man of most orderly mind, introduced me to his bees, which were housed in a line—a straight line of hives, all precisely alike in shape, colour, and size, faultlessly clean, and arranged upon substantial pedestals with stone tops, all of which were accurately equidistant, with about 2ft. interspace. The hives, moreover, were backed by a very long and very regular wall, which formed a side of a painfully methodic kitchen garden, and before them ran a path, wearying by its length, and as straight as an arrow. When we first caught sight of the apiary, it looked like a huge, brown caterpillar, each segment of the body of which was represented by a stock; and I saw at once some ground for the failure complained of, for, had all been devised with an idea of puzzling and confusing the poor bees, in order that, so far as their homes were concerned, they should not distinguish "t'other from which," one could have pronounced the arrangement perfect. It is obvious enough that a dead similarity, not only in hives, but in their surroundings, must lead to a good deal of visiting, begetting the excessive familiarity which, if not breeding contempt, will lead

almost certainly to robbing* and disaster. But in addition, with such an arrangement as I have been describing, any poor queen seeking maternal honours, in leaving her hive has a task put before her almost as difficult as learning to distinguish a special note on the keyboard of a piano; and what wonder if she, the hope and promise of her colony, bewildered by our mistaken notions of trimness, fail, and, entering at her return the wrong door, fall by an alien dart, and so leave her proper home to extinction? We must not sacrifice the picturesque to the symmetrical, unless we can place our stocks some distance from each other. Long lines of similar hives must be avoided, unless characteristic landmarks, such as shrubs and trees, rise amongst them. Let variety in colour, if not in form, come to our aid, and then we shall not need the resource of fixing near the flight-hole of a stock containing a queen approaching the period of mating, some conspicuous object, such as a leafy bough, to guide her at her return.

Errors made by bees in finding their stands is the main cause, probably, of a difficulty which has sorely puzzled many. During examination, especially in windy and uncomfortable weather, an encasement of the queen in her own hive is commenced; or, when the hive is opened, she is found already balled, as though she had been amongst strangers. The occurrence is comparatively rare, but is observed, as would

* The close placing of hives does not lead to difficulties, if the bees can distinguish easily between them; and in robbing, it is usually noticed that the war rages, not between close neighbours, but between stocks lying some distance apart.

be imagined, most frequently by far in early spring; for it is presumable, that at this part of the year bees are least conversant with the exact position of their own entrance. Careful watching of this phenomenon has thoroughly convinced the Author that the trouble is at least frequently commenced by an assault made by one or two aliens, which causes the queen's own children, under a misapprehension, to follow suit, until all the colony is in the same condition of ferment as though a strange queen had been dropped amongst them. Bees, as social creatures, can only act in concert because they can give and receive information from one another, and they are liable to be made the victims of a mistake which, under general excitement, cannot be rectified (see page 260). They all, in the circumstances supposed, believe that a strange queen is in their midst; and then freeing her from her antagonists, and putting her on to another frame, does not mend matters, for the hissing multitude no longer recognises its own mother, whom they are quite likely, if unrestrained, to hug to death. We have, no doubt, before us the reason why many colonies turn up queenless in the spring. Repeated and unseasonable examination tends to beget the evil, which can only be met completely by re-introducing the queen in her own stock, either by caging, or—as I should distinctly prefer—by removing with a few young bees, and re-inserting at night, as explained at page 345.

Uniting—the name given to the joining of two or more colonies—is usually both simple and safe; yet occasionally obstinate cases occur, which may land even the experienced in disappointment. In the

case of swarms, failure is scarcely possible. Bees, in the absence of combs, very rarely fight; and swarms, filled as they are with honey, never do so (see page 148). It is only necessary to throw them down in front of the hive they are to occupy, and allow them to mingle as they enter. Of the queens, one only will be allowed to survive; and it is wise, if these are regarded as of unequal value, on account of difference in age or race, to remove the inferior: but no harm, *per se*, will result from permitting the bees to settle the question. If one swarm has been established even a few days, a second may be added to it, in the evening, after flying is over, if, at the moment the second lot is thrown down, sufficient smoke be driven in at the hive mouth to send back the guards. Watching is now desirable, and any indication of fighting should be followed at once by a fairly liberal use of the smoker. Where tiering hives are used, the second swarm can conveniently be added in an under storey, but the first swarm must be lifted with much caution, lest the growing combs suffer fracture.

Additions to established stocks require more care; and especially is this true with condemned bees (page 369), or they may be "killed to a man," and so be a source of weakness to those they were intended to strengthen. If the condemned bees, as is frequently the case, are empty and hungry—and such are never easily united to those on combs—they should, despite the trouble it involves, be first fed, or, at least, copiously sprinkled with syrup, when they may thus be united to a frame hive. Jerk or brush the bees

from their frames, practically making them into a swarm (page 258). Throw down the condemned bees at the entrance, and, when they are running in freely, pour the rightful owners upon them. Stirring together with a card will make an amicable union the more certain. It is, perhaps, less troublesome to shut up the stock to be strengthened to a few frames by a division-board, covering their portion of the hive carefully by the quilt, the remainder of which is turned back for a reason presently apparent. The condemned bees are now poured into the unoccupied part, and as many combs, containing some honey—and, if convenient, brood—given as may be needed for clustering. The residue of quilt is put over them, with a corner kept raised by a bit of stick, to permit them to draw in, and to furnish a temporary flight-hole. After two days, the condemned bees will have become a small stock in fairly normal condition, when, the undesirable queen and the division-board being removed, the combs of the two lots may be alternated with very little risk. In reference to alternation of combs, Mr. Simmins gives the following excellent advice: "The hives to be operated upon should first have the whole of their combs fully exposed to the light, and each seam of bees divided by drawing the frames so far apart that none hang from one to the other." It is better to unite in the evening, to use smoke in fair amount, and to handle the combs with considerable gentleness.

If empty hives are at command, it may be preferred to first instal the "condemned," as previously described, but in one of these placed by the side of the home

they are presently to occupy. The two sets of combs, in forty-eight hours, are, after the displacement of one queen, alternated as before in the one hive. Many recommend that the remaining queen be caged at the time of uniting, and liberated forty-eight hours subsequently; but I should, for myself, only regard this as very exceptionally necessary. Neither do I now practise scenting by sprinkling both lots with thin syrup to which some aromatic substance, such as essence of peppermint, has been added, although, probably, scenting adds a favourable element to the operation.

Bees on frames not interchangeable may be brushed from their combs, and then treated on the same lines as "condemned" lots, their brood, if any, being saved by "Transferring" (which *see*). As previously remarked, indications of fighting should be checked by smoking, and, in bad cases, the addition of two or three drops of creasote to the burning material will have a very marked effect. Applying smoke three or four times, at intervals of a few minutes, with heavy thumping on the hive side, will, almost invariably, permanently restore order.

In uniting queenless lots with others, Mr. Raitt,* instead of alternating the frames, draws those belonging to one of the colonies to one side of the hive, placing in the middle a division-board,† or old empty comb, with its edges smeared with crude carbolic acid by means of a feather; he then places the other stock at the opposite end of the same hive.

* *Bee-keeper's Record*, page 74, Vol. iii.
† Necessarily loose-fitting.

No bees pass the division-board until both lots have acquired the same smell, and all "fight," by this means, is taken out of them.

It may happen that we discover a stock (−Q) to have lost its queen at a season when, presumably, a successor could not be fecundated; while in a distant part of the apiary stands a colony (W) so weak as to need assistance: the union of these would, therefore, appear most desirable. Of course, we may bring the two up side by side by slow marches, as described under "Moving," and then unite into one strong stock by alternation of frames, or by Mr. Raitt's method—standing the new-made colony between the stations just previously occupied by the two; but the moving may generally be avoided by a little ingenuity. *E.g.*, if the queenless lot stand near one of fair strength (S), after smoking both S and W, carefully leaving the queen behind, carry as many combs with brood and bees from S as will make W strong.

$\boxed{-Q}$ ns $\boxed{S}$ $\boxed{W}$

S is now weak, and may be united to the queenless bees on the new station (ns). Some will, of course, return from W, but they will join their old queen, and so no mischief will follow.

Our greatest difficulties are likely to arise with stocks that have been long queenless, and in seasons when the bees can fly freely, and yet gather nothing. When nectar abounds, provided always that the newcomers have not empty honey-sacs, there is a general desire to cultivate the arts of peace; and when the weather is cold, all prefer comfort to chivalry. In

untoward conditions, it is wise to preserve the displaced queen until we know that the one we have selected is safe.

Twin stocks unite peaceably of themselves if, one or two days after the displacement of one of the queens, the division-board be lifted (see page 303).

Uniting before the honey harvest often gives us a gigantic stock for two not large enough separately to crowd into supers; and when the honey season has slackened, so that we can make a forecast of what our stock will be, preparation to meet the rigours of winter, by uniting all weak lots, can hardly be undertaken too soon. Should small nuclei still remain, three or four of these can be put together, care being taken that the store-combs occupy the sides, and the brood the centre. The danger is slight, since small stocks unite more readily than larger, and several families put together seem to lose mutual antipathies more quickly than where there are only two. Should the nuclei have previously stood together, the question of station gives no trouble; but if not, make the union on a cold day, so that the bees will adhere to their combs, give a little smoke, and stand a board in front of the entrance (page 274), and but few bees will be lost, since the internal arrangements of the hive will be so changed as to attract their attention.

Supercession of queens by their own bees, when from age or defect they are found to be failing (page 326), has already been noticed, and it is a question of practical importance to determine whether the bees should be allowed to follow their instinct, or the beekeeper should himself supply a young queen at times

and under circumstances which he may deem most desirable. The answer will a good deal depend upon the management of the apiary. It is admitted that queens are generally beginning to fail in their third season, and this will be emphatically true where they are required to lay heavily and constantly during the spring and summer. Unquestionably, the best results cannot be obtained unless the queen is equal to every demand in the early part of the season, which is in itself a reason for superseding her at the end of her second year of work; and if it be true that we, by careful management, are securing queens of higher quality than can be, in the nature of the case, produced under the swarming impulse, the advantage of artificial supercession admits of no doubt.

The whole bearing of the chapter on "Queen-raising" shows that that selection which has had for its object the maintenance of the race, does not secure so fully the highest interests of the honey-producer as he may secure them by wise interference. But if our strain of queens is undergoing no improvement, and we are not striving to breed out the swarming impulse, it must still be remembered that, if the mothers of our stocks are allowed to grow aged, the bees may be awakened to the necessity of replacing them at the wrong period of the year, or when eggs are not at command, nor drones existent, and so snatch from us the profit our stock might have produced, giving us instead the losses of queenlessness or the annoyance of a drone-breeder.

The artificial removal of queens will not be wholly determined by age. Unsatisfactory ones, which do

not rise to the occasion, or whose bees possess undesirable qualities, or are deficient in desirable ones, so that a poor record is made, will retire early, while good average queens will be only rarely entrusted with the work of a third season, exception, of course, being made with those whose high quality has raised them to the rank of queen mothers.

A register of operations is helpful where but two or three stocks are kept, but it is essential in a larger apiary, unless we are content to have vexatious failures, and their attendant losses, through oversights or omissions. Most men are incapable of retaining, by the unaided memory, such a chain of observations as will permit of accurate deductions respecting any stock, or the characteristics of its queen. In the absence, then, of any system of note-taking, experience, which depends upon our grip of observations in their sequences and mutual relations, is not likely to grow rapidly. How, then, shall our notes be made? In a book; or shall they remain attached to the stock? Both methods would appear to have their place. The book (the hives being numbered) will preserve for reference facts observed at a general inspection of the apiary, made at a set season, such as spring or autumn, and may enable us to exercise unusual caution in looking after the wants of any stocks whose condition, from weakness, shortness of stores, &c., may give occasion for anxiety; but the most serviceable notes, in my judgment, are those which centre round the queen, and, with a separate slate, or large card, for each colony, and which follows the queen in her movements, I have accumulated memoranda which have been

of inestimable value in my study and practice. In this way, the mother of the colony has what may be called a ledger account, which is connected in such a manner as to give rapidly a mental picture, not only of the queen, her parentage, and her doings, but of our treatment and its effects. Of course, each bee-keeper would design for himself a system of symbols and contractions, so as to express much in a little space.

Mr. Root sells a printed card, which he calls a "Queen Register," the exclusive purpose of which is to mark the current condition so far as the queen is concerned. The date is determined by two pins revolving like clock-hands, and which point to one of the eight months of activity between March and October, and to one of the numbers between 1 and 31, arranged in a circle. The third indicator, rotating like the others, may be set to either of the following words placed around it: "Cell," "Hatched," "Laying," "Approved," "Not Approved," "Missing," "Eggs," "Brood," which it is clear are intended to register the different points reachable in queen-raising. These cards are only intended to have a temporary value. My notion of notes extends to observations, as before expressed, touching system of treatment and results, with such a brief chronicle of conditions at last examination as shall, as far as possible, render subsequent inspection unnecessary, and so save disturbance to the bees and loss of time to the bee-master.

CHAPTER IX.

THE PRODUCTION OF HONEY.

Honey: Where Stored Naturally—The Advantages of Supering—Large Supers v. *Sections—Glass Supers: to Fix Combs in—Telescopic Supers—Clearing Bees from Supers—Bar Supers—Divisional Supers—Dovetail Sections—Folding Sections—Cutting and Fixing Foundation—Lee's Sections—Section Crates—Separators—Divided Crates—Brace Combs—Invertible Crates—The Principles Involved in Extraction—Uncapping—How to Secure Comb Honey—The Application of the Extractor—The Size of the Brood-nest—Methods of Supering—Treatment of Swarms for Honey Production—Foundation in Section: Reasons for and against—Transferring Comb to Sections.*

BEE-KEEPING, which has been gracefully called the poetry of agriculture, has an intensely prosaic side; it is the question of food and money, and this now most directly must occupy our attention, while we seek the guidance of general principles.

The bee stores its tempting sweets at the parts of its habitation least accessible to an enemy, and where, during the grip of winter, the vital heat of the colony should keep the edge of the store sufficiently warm

to permit of its being consumed as occasion may require; we find, therefore, that the brood-nest is kept naturally near to the entrance, while the honey lies above, behind, and at the sides. Wild bees, seeking out such hollows as may best suit them, are forced to accommodate themselves to the varying forms of the cavities in which they build. Sometimes, their combs are of necessity stretched out in great plates, few in number; at others, they are numerous because individually small; but the general principles indicated with regard to the position of the honey always assert themselves. We must also observe that combs are built readily downwards, but lateral extensions are made irregularly and slowly, while upward building seems to present accumulated difficulty. All this is true, because it is the nature of the bee to build from its roof, to have no cavity unoccupied by comb over the cluster, and to extend its nest laterally, though not until after it has established full communication with its entrance. These facts need attention, since our hives and methods, to give the best success, must be modelled in obedience to their teaching.

Ancient is the practice of taking advantage of storing *behind* the brood-nest while the colony is left intact (page 82), and, reaching down to our own day, the straw skep is often deprived by having its side comb of honey excised; but here, usually, an advance is made upon primitive methods by placing over an opening in the roof of the skep a cap, or super, to which the bees have free access to deposit their wealth, while it is, practically, a distinct chamber so far as the queen and brood-nest are concerned.

In this partial separation of the brood-nest from the honey-chamber, the contents of which man appropriates, several advantages are gained: Firstly, comb in the body of the hive, however situated, is much more liable to be visited by the queen, and spoilt for table use by the deposition of eggs, than is that in superadded surplus receptacles. Secondly, the close contact of nursery work, and the continual tramp of the busy throng, soon mar the dainty purity which distinguishes comb when first modelled by the wax-workers. Thirdly, the honey of the separated chamber is scarcely ever mingled with pollen: the latter substance is the staple material for forming brood and queen foods, and is therefore normally placed, for the convenience of the nurses, within reach of the cells containing eggs or larvæ. On the other hand, it is scarcely required at all in the winter, honey being then needed to maintain temperature; and since pollen cannot, like honey, be transferred from cell to cell, but after storing must remain until it is consumed, it is not mixed by the bees with that store that is distinctly marked off by their instincts as for winter use. Pollen is also more completely kept out of our supers by causing them to be furnished with thick combs, whose deep cells are commonly avoided by the pollen-gatherers.

With the introduction of the frame hive, the productiveness of individual colonies was greatly increased, while it was made evident that bees could be induced to store in any receptacle, however placed, if only sufficiently connected with the brood-nest to be warmed by it. From this it is apparent that supers, all things considered, yielded the best results, and not

many years since those of huge proportions were the great object of the bee-keeper's ambition; but, in spite of the handsome appearance of delicate honeycomb in a mass weighing, perhaps, 100lb., the difficulty of getting supers completed without the bees swarming, their tenderness (scarcely permitting of their transport by the usual means of conveyance), together with their unsaleability, have obliged them to give place to small boxes of honey, called sections. The complete dismissal of supers from our exhibitions and competitions is undesirable, and a disposition to again encourage their production is apparent, but our space will only permit of a short reference to them.

Comb-building needs high temperature, and so keeping a super warm is a primary point, or the bees will only very reluctantly enter. Whatever be its material, it is highly desirable to securely close all interstices between the hive and it, afterwards carefully sheltering from rain and sunlight. For general beauty of appearance, no material can equal glass; but it requires closely covering, both because exposed glass will allow heat to be dissipated through it, and the moisture rising from the hive will be condensed, so bedewing the super within that it will be impossible for the bees to attach their wax tracery. A non-conductive jacket should be provided, after the fashion of a teapot cosy. A double thickness of cloth or stuff, with wadding between, answers perfectly; but, lacking such good coverings, a couple of brown paper bags, one within the other, put down neatly into place, will render signal service. Bees often refuse to enter if this condition be neglected, but, should they commence

operations, much honey is wasted as food to enable the wax-workers to replace that heat which is constantly leaking through the super walls.

Bees are quite unable to walk upon the under surface of damp glass, and only do so with difficulty if it be dry (page 125, Vol. I.), so that they cannot, under any circumstances, support from a glass dome the weight of a curtain of wax-workers. Should our glass super take this or any comparable form, combs or foundation must be attached to give the bees foothold. Cut some nice, clean pieces of comb, then warm the glass over a lamp, when the attachment may be made by simply pressing the pieces where it is desired they should remain. They adhere with sufficient firmness, and the bees soon make them secure. If foundation be used, it should have been bleached by exposure to light during several months, or its edge will match badly with the rest. The comb or foundation may be arranged radially or in some simple pattern, so as to improve the appearance of the super when complete, and, by the aid of foundation, simple and very pleasing devices are producible within supers with plate-glass tops. Deep supers are not adopted so readily as sections, because of the distance the first workers have to separate themselves from the main body. Mr. Fox conquered this by using supers telescopic in structure. These were constantly increased in perpendicular height, so that the bees were kept struggling to fill the gap formed by the repeated carrying up of the roof.

When all is completed, the complexity of the form of the comb, and the weight of the super, often

make the banishment of the bees far from easy. If no honey-board has been used, the super must be cut from the hive by a thin wire, and then propped up from $\frac{1}{8}$in. to $\frac{1}{4}$in., and the crack so closed that no bee escapes. Leaving it from thirty to forty minutes will enable the bees to clear up bleeding honey, and repair somewhat the broken edges of the cut cells. It may now be carried to a cool, shady spot, gently inverted, and covered at its mouth with a cloth. The jacket should remain on, or the light passing through the glass will confuse the bees in their efforts to find a way of escape. Every few minutes the cloth may be removed, the bees shaken from it, and as many permitted to fly as will do so. If robbers make their appearance, the cloth must be immediately restored to its place. If the super be so large and heavy that inversion may cause bleeding, or if it be not wholly sealed, it should be raised on blocks within a case, into which the bees will by degrees pass. If this case be provided with a trap, all trouble is at an end. The most simple, although not the safest, form is made of tubes of perforated zinc, $\frac{1}{2}$in. wide—or rather less—by 4in. or 5in. long, and pointing towards the light, fixed into the side of the box, so as to be flush within. Tubes not perforated are more likely to be entered by robbers, as the odour at the end of the tube will direct them to the honey. With perforated tubes the odour escapes against the box, and keeps the little thieves fidgeting at the wrong spot. Instead of tubes, my well-known five-pin trap may be used. Over a large opening in the box is placed a thin piece, slanting at about 45° to the horizon; in this are

made clean holes $\frac{1}{4}$in. in diameter. Four rather small pins are driven in—two above and two below each opening, each pair so close together that a fifth pin can lie between the two pairs, exactly across the centre of the hole, while its head cannot slip down between the upper two. Instead of using two pins above the hole, I prefer a pin deprived of its head, and driven in somewhat like a bell-hanger's staple, to suspend the centre pin running across the opening. Three or four of these will be sufficient. The bees, coming to the light, press up the pin which crosses the hole; it freely rises, and gives them exit; while entry, as it falls back into position, is effectually barred.

The difficulty of dealing with large supers directed attention to methods of easy and cleanly sub-division. The Stewarton Super, with combs attached to bars which could be distributed with scarcely the rupture of a cell, pointed the way to progress, and shallow frames were introduced, capable of storing 2lb. or 3lb. of honey. These were arranged in supers, like the frames of the hive below. Next followed the divisional super, consisting of a series of wide and shallow frames, with a narrow bottom rail, raised $\frac{1}{4}$in. from the ends of the sides. The wide frames were braced side by side, after the fashion of the Giotto (page 89), and were closed at the ends by thin boards, usually carrying a small, circular window, to enable the bee-keeper to judge of their condition; for when side frames, in such an arrangement, are complete, it is practically certain that the central ones are so. The wide top bars meeting together made the super

necessarily a one-storey affair only, but the combs were, if only straightly built, most easy separable. They were clean and handy, easily cut from the wood, and, consequently, marketable. The divisional super is the clear prototype of the section, and the passage from one to the other was but a step. With the advent of the section, a new era opened in the production of, and demand for, comb honey, as now the waxen cell, ready to yield its unsophisticated contents upon the slightest pressure, could appear upon the table with a neatness, finish, and beauty which before had been unattainable.

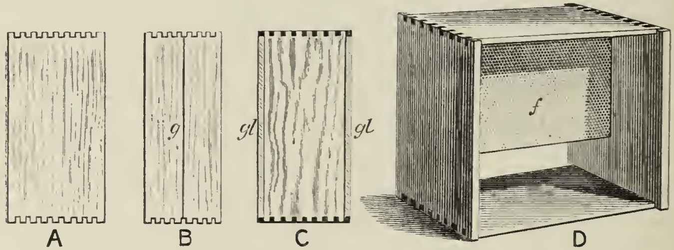


FIG. 104.—ROOT'S DOVETAILED SECTION BOX.
A, Side Piece. B, Top Piece—*g*, Groove to receive Foundation. C, Top View of Box complete—*gl*, *gl*, Glass. D, Box with (*f*) Foundation.

Many questions yet remained for settlement. Interchangeability of frames is hardly more desirable than was some mutual understanding as to standard sizes in sections, for many forms were already upon the market; but Mr. Root did much—at least, in establishing *a* standard—by producing cheaply an ingenious form (Root's Dovetailed Section), which so nearly met the requirements of the case that it has yet many admirers; while for stability and portability no successor has excelled it. It is made of clean bass-wood

—*i.e.*, American lime—each box consisting of two narrow and two wider pieces, planed on one side only (the outer side), as bees fix their comb more easily to wood as it leaves the saw. The sides A are about $1\frac{9}{10}$in. wide, and $4\frac{1}{4}$in. long; the top and bottom pieces being the same length, but $\frac{1}{4}$in. narrower. The parts, after they are brought to the correct thickness, are clamped together in hundreds, and run over a "gang" of grooving-saws (thick, circular saws), which, cutting grooves into the ends of the clamped-up pieces, leave eight notches at each end of the separated sides, and seven in those of the top and bottom. The eight projections (dovetails ?) of the top and bottom fit into the hollows between the nine projections of the sides with such accuracy that knocking them together with a hammer gives a box with tolerable—perhaps sufficient—rigidity; but a touch on the dovetails of thin, light glue, which I have always used, holds the four pieces together with astonishing tenacity.

The little labour glueing involves is, in my judgment, more than compensated by the subsequent ease and freedom with which these sections can be handled. They are then beyond injury, and instead, when filled, of depending upon the stiffening given by the comb, and sometimes losing a bottom rail in removal, the sections yield to the tender cells the fullest protection, preventing the bleeding and depreciation too commonly attending the use of flimsy boxes.

The greater width of the sides gives entrance-way to the bees from below, as the top and bottom pieces are kept $\frac{1}{4}$in. apart as the sections stand side by side. The corresponding openings above permit of

the sections being tiered one upon the other, as hereafter described. This arrangement also provides for an exceedingly simple and secure method of glazing. The glass (*gl*, *gl*, C), lying against the top and bottom, is held in place by the sides. The addition of strips of gummed paper makes the package as complete and portable as can be desired. So cheaply are the sections turned out, that the whole honey-case, including glazing and full-sized foundation, will scarcely exceed one penny in cost.

The box just described, when properly filled, holds about 1lb. of comb honey, and eight can be just fitted into the Langstroth frame, so largely used in America, while six of them can be placed together in the compass of the British standard. Its capacity seems also to have better suited public fancy than those that are larger, and so other makers, in consequence, in introducing new forms, have retained, in many instances, the size first adopted by Mr. Root—viz., a box 4¼in. square outside.

Folding or one-piece sections are now most generally used. These are made, preferably, of white poplar, and, like their predecessors, travel admirably in the flat. Their peculiarity lies in their folding at three angles, and dovetailing, as before, but at one angle only. In order to make bending to a right angle possible, V-shaped grooves (*vg*, *vg*, Fig. 105), are cut by machinery, almost dividing the wood. These grooves, after folding, appear as a mitre (F), where *b* indicates the point of bending. Some prefer the flat plough joint, E. The wood, especially if dry, is likely to break during the bending process; but this may be

entirely prevented by standing a number of sections together on edge, and pouring a stream of hot water along the line formed by the grooves (*vg*, *vg*, B) lying one behind the other. Driving the dovetails together completes the operation; but the box is less solid than quite satisfies my notions of the fitness of things, and I strongly recommend the use of thin glue, as

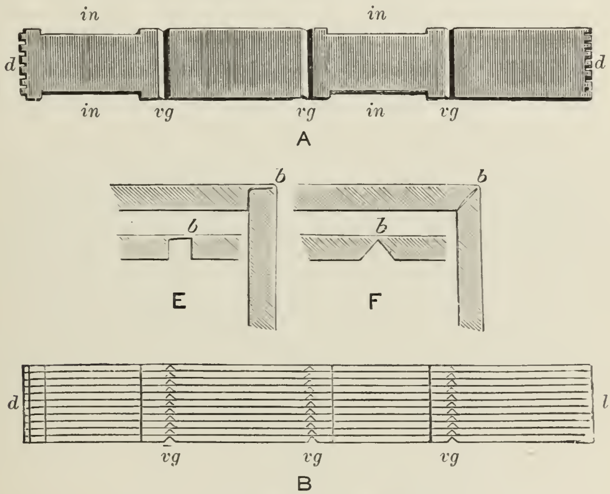


FIG. 105.—FOLDING SECTIONS IN THE FLAT.

A, Single Section ready for Folding—*in*, *in*, Incepts; *vg*, *vg*, V Grooves; *d*, *d*, Dovetails. B, Edge View of Sections ready for Watering—Letterings as before. E and F, Angles formed by Plough and V Groove respectively—*b*, *b*, Points of Bending.

before suggested. The objection of the time absorbed is not valid, for the use of glued and unglued sections convinces me that the latter require much more time in handling than the former, while they frequently break, and sometimes are the cause of a good comb being wrecked. In bending up the sections, a folding-block (A, Fig. 106), into which the section fits

with very little play, is highly serviceable; for, while it holds steadily the upright carrying the dovetail, the overstraining of the joints, so likely to cause fracture, is prevented, the section being at the same time put up rectangularly. It will be noticed that the incept (*in*) provides passage-way for the bees, as it is secured by the narrow top and bottom of the Root. Incepts are now being made on all four sides, an improvement hereafter fully explained. Straight building, as with ordinary frames, must be secured by the use of some kind of guide—either a starter or a larger piece of foundation—unless we can fill our sections with comb from the beginning.

We must now discuss how the foundation shall be cut to the greatest advantage, and put into position. The size of our sheets of the thinnest make (for that used in the hive body is much too stout, and would spoil the comb honey for table use) will, to some extent, determine the size of the pieces for the sections, a question respecting which opinions differ widely, as we shall presently see. Boxes $4\frac{1}{4}$in. square outside, and so 4in. square inside—if we desire to use foundation to the fullest extent—may even carry pieces nearly 4in. wide, and 3in. or a little more in depth. To cut these, Mr. Root recommends two boards, one made of strips of the width of the pieces required, and another similar board, whose strips are as wide as the pieces should be long. The strips are just far enough apart to allow a knife to run between them. The two boards are placed together with the sheet intervening, and the cuts made from the two sides, dividing the sheet into the forms desired. I consider

it to be far more convenient and quicker to use one board only with my arrangement. Suppose, for the sake of illustration, that the best size is 3in. by 4in. If the first strip be 1in. wide, and the next strip as much wider than the first as the difference between the width and depth of the pieces, then the upper edges of the strips being fixed 3in. apart—*i.e.*, the depth of the required pieces—their lower edges will be 4in. from each other—*i.e.*, the width of the pieces. Reference to B, Fig. 106, and the figures marked upon it, will make this evident. The third strip will be 3in.

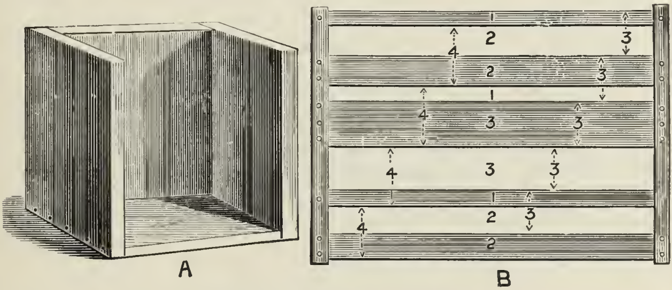


FIG. 106.—SECTION APPARATUS.
A, Folding-block. B, Gauge for Cutting Foundation for Sections (the Figures imply Inches).

wide, when the cut at its lower edge will again give the 3in. interval, after which the series starts as at first. The sheet, or two or three sheets of foundation, are placed on the table. The board is placed over it, or them, and 3in. strips immediately cut. Turning the board half round makes the previously horizontal strips perpendicular, when cuts, still made by the right hand, from the other edge of the strips, will divide into pieces 4in. wide. These are then gathered up, and kept in correct position one over the other, lest any foun-

dation should accidentally get suspended sideways (see page 217). Those who try this arrangement will find in it great comfort and convenience.

The foundation cut up has now to be fixed. Some use the well-known Parker fastener, which squeezes the foundation into the grain of the section roof; others favour a tool much resembling a bradawl handle, the large ferrule of which revolves like a wheel, and, being guided by a stop, squeezes the foundation until it adheres; the piece which has the upper $\frac{1}{8}$in. or $\frac{1}{4}$in. thus

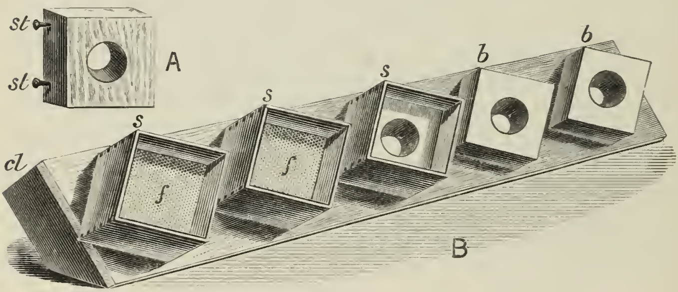


FIG. 107.—APPARATUS FOR FIXING FOUNDATION.

A, Single Block—*st*, *st*, Stops. B, Range of Blocks on Stand—*s*, *s*, *s*, Section-boxes; *f*, *f*, Foundation; *cl*, Cleat; *b*, *b*, Blocks.

held tight is now turned to a right angle, so as to hang in position. Many similar devices are employed, and they have the one advantage that melted wax is not required; but, for neatness, finish, and certainty, I prefer fixing by the aid of melted wax, and in this preference I find myself in excellent company. The most simple tool is a block (A, Fig. 107), with a thickness more than half that of the section-box. Nails, to act as stops (*st*, *st*), are driven into its sides, so that the face of

the block enters the section far enough to hold the foundation in the central line. The block, which it is best to wet before using, is taken in the left hand; the section, inverted, is put over it, when the finger ends press the top of the section, and hold it firmly against the block. The foundation is placed, and the whole is held "angling in two directions," so that a drop or two of wax from the smelter (page 176), run along the edge of the foundation, firmly cements it to the section top. By the time the smelter is returned to the heating lamp, the wax will have cooled sufficiently to permit the section to be turned into the upright position by a rotation of the wrist, when it may be placed in the crate ready for use. I have shown that, after all things are prepared, seven sections may be thus waxed within the minute. The hole in the block is important; it gives thumb-hold, allows the air to escape when the foundation is dropped into place, and permits of the piece, if it settles down awkwardly, being adjusted immediately.

All who wax many sections will find my plan, now appended, an improvement upon Mr. Doolittle's, for it leaves both hands free, while it is extremely rapid and satisfactory. A piece of board (B, Fig. 107), long enough to support five or six blocks, has a cleat (*cl*) at each end, so that it will stand at an angle of 45° to the horizon, as in the Figure, or perpendicularly if turned over upon its other edge. The blocks are a little less than half the thickness of the sides of the section, thus holding the foundation centrally. They are put on at an angle, so that the face, "angling in two directions," may cause the wax to run

down as already described. Holes are made in the blocks, for the reason before given, and to permit the fingers to move the foundation from either face. The sections are placed on the blocks as at *s*, *s*, *s*, the foundation (*f*, *f*) added, and the waxing done *seriatim*; the whole board is now turned over, when the sections hang upright, ready to be removed to the crate, for placing over the hive. With two of these a very large amount of work may be accomplished, while there is no temptation to turn over the sections too hurriedly,

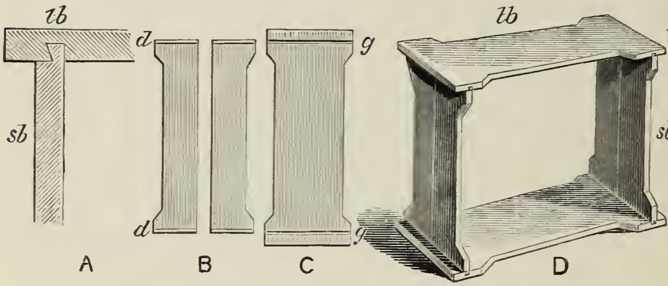


FIG. 108.—LEE'S DOVETAIL SECTION.
A, Joint, exact size—*tb*, Top Bar; *sb*, Side Bar. B, Side Bar—*d*, *d*, Dovetails (Scale, ¼). C, Top or Bottom Bar—*g*, *g*, Grooves. D, Built-up Section—*l*, Lug; other Letterings as before.

cracking the wax, and inviting a breakdown when the bees are starting operations.

Mr. Lee, by applying his dovetail joint to sections, has produced a form which presents not only novel but useful features. The construction of the joint—seen of full size at A, Fig. 108—needs no further comment than it received at page 192. The sides (B) are divided like the top bars of his frame, similarly to which the section is put together on a block, itself a modification of Fig. 54. The foundation is held

securely between the halves of the split side bars, and the section has enough and to spare of that firmness which the folders often lack. By a plan, in my idea far too inconvenient to be largely adopted, three of these sections are placed in a frame (*fr*, Fig. 109) the top and bottom bars of which are cut to follow the outlines of the top and bottom bars of the three sections standing between them. It will be noticed that this section, unlike Figs. 104 and 105, has incepts (*in*, *in*) on its sides* as well as above and below, so that, when the frames carrying them are placed side by side, and close together, in an upper storey, as is intended, bees can not only pass from storey to storey, if several be placed one over the other, but they can travel horizontally between the sections. Such are called four-way sections. In addition, the short lugs (*l*, Fig. 108) keep the boxes a bee-space (*bs*, Fig. 109) from each other, permitting the bees to pass to each face of their work. These facilities make unnecessary the unsightly openings (popholes) between the section and the comb, the latter, as a rule, in consequence, being made to fill the section, to which it is evenly attached in every part. The reduction of the width of the side has another advantage: it gives the wax-worker opportunity of here finishing the attachment cell (see page 177, Vol. I., and page 223, Vol. II.), because she can stand in a position which permits of modelling the cell wall from both its sides. This says much in favour of rather narrower sections than those frequently used. In

This important improvement originated in America, and must be generally adopted.

wide ones the difficulty explained in Vol I. tells much against the completion of the comb to the wood, the latter, in consequence, standing so far out in front of the honey as to materially reduce the beauty of the appearance of the section, by throwing a shadow, and giving an impression of incompleteness. Mr. D. A. Jones, at his visit to this country, expressed to the Author, more than once, the gratification he derived from noting that Vol. I. had, theoretically, deduced what he, in actual practice, had found to be true, but for which he had been quite unable to give an explanation.

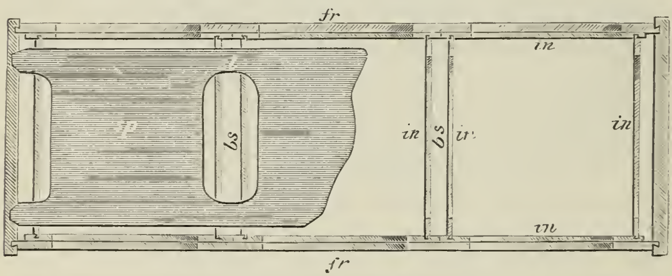


FIG. 109.—SECTIONS IN FRAME (Scale, ¼).
fr, *fr*, Frame; *in*, *in*, Incepts; *bs*, Bee-space; *sp*, Separator; *sl*, Slot in Separator for Bee Passage.

The sections under discussion can be used with what has been called the "side" downwards, when they can be arranged in crates, as at Fig. 110; and as the lug (*l*, Fig. 108) gives half bee-space, they can be piled on each other *ad lib.* So standing they admit of a modification which greatly enhances the beauty of the whole thing. The bottom rail, in the sections now referred to, is formed of a single slip of glass, carried by a square groove instead of a dovetail,

and held by so arranging the joints above that the sides tend to spring from the right angle towards each other. Mr. Raitt exhibited sections with a glass bottom rail as far back as 1875, and says of them: "The combs in these are almost always fastened down along their whole length (the glass being thin and somewhat narrow), and the honey is stored right on to the glass, making a fine show of colour." Sections with all sides glass are rather impracticable and over fragile, but a crate of such exhibited by the Hon. and Rev. H. Bligh I thought to be the most beautiful object of the kind I had ever seen.

Sections are sometimes placed by the side of the brood-nest, in carriers or frames, as, by example, in the "Eclectic" (page 78). Six of the $4\frac{1}{4}$in. by $4\frac{1}{4}$in. may be very conveniently accommodated in a carrier of the standard size, having a zinc bottom rail, which practically does not increase its depth, while it is sufficiently stiff, because one edge is turned up at a right angle. One side, with an inner loose piece, is arranged as a parallel wedge, which tightens up the sections, and yet, immediately it is withdrawn, makes all free for removal. The separators, more particularly explained hereafter, are permanently fixed, and prevent the sides of the frames from being driven beyond the correct distance from each other. In my judgment, sections on the side of the brood-nest give much trouble, and are, all things considered, undesirable.

The framing which holds the sections together, so that they can be moved bodily, and placed over the hive, is called either a rack or a crate, the former term being generally applied when no box-like sides

are used. Crates are made so cheaply, and are, withal, so much more serviceable for preserving sections after they are taken from the hive, that they alone need description (Fig. 110 will give a general idea of a usual form). The sections are arranged, in three rows, within a ring of wood $\frac{3}{8}$in. deeper than the sections themselves, which stand on rails (*r*, *r*, Figs. 110 and 111) running from front to back of the crate. Each rail is formed of two pieces, the lower supporting the corners of the sections, while the upper stands between them, giving the bees liberty

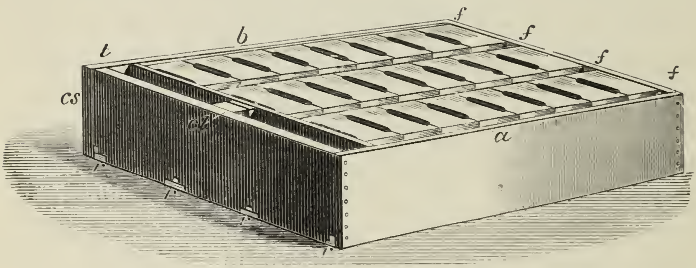


FIG. 110.—SECTION CRATE FILLED.
cs, Crate Side; *r*, *r*, Rest Rail for Sections; *t*, Tightening-board; *f*, *f*, Finger Space.

to travel all round their combs, and so avoiding pop-holes, as previously explained, and, further, providing finger-room (*f*, *f*), much facilitating the removal of single, filled sections. The sections of some makers are supported on a zinc sashbar (B, Fig. 113). They readily slide backwards and forwards upon the rails, but need to be kept firmly pressed together, so as to prevent the bees inserting their messy-looking propolis. This is accomplished by a tightening-board (*t*, Fig. 110), driven forwards by a spring or clamp (*cl*).

The removal of the latter loosens the board, and puts each section individually under command at once. If a single storey, or any number of storeys of sections be used, calico will be placed above, to close the openings, and then jacketing, or quilt, as may be deemed necessary. If storey be tiered on storey, the crate will provide intermediate bee-spaces, the bottom rail of each section being left free, a point which seems very desirable in securing nice finishing of the comb at the lower edge.

Such a crate of sections as we have been describing, placed, at the opening of an abundant honey-flow, over a stock greatly in need of increased accommodation, would not only be taken to at once, but work would also be commenced in all the sections simultaneously, and, as a result, the combs would grow *pari passu*, their faces approaching each other until room for the little labourers is alone found, when sealing with dainty caps completes the work. But this ideal exactness is only very rarely attained. If the bees are not greatly overcrowded, the addition of a section crate gives them more space than they can instantly fully fill, and a cluster takes possession of its central part, as here, immediately over the densest masses of brood, the temperature needed for wax secretion and modelling is the more easily kept up. The first-constructed combs then maintain the start they have (see page 269), and so intrude into the adjoining box, preventing glazing, causing bleeding in separating, unequal weight in the several sections, and all-round annoyances, which half nullify the advantages of the section system. To overcome these

difficulties, the separator has been introduced, as a necessary evil, for it is an additional complication, while there can be little doubt but that it is regarded by the bees with a wee prejudice. The separator, placed between the faces of each line of sections—running, *i.e.*, from *a* to *b*, Fig. 110—may consist of tin, zinc, or thin wood; but the first is certainly most desirable. The bees, as before, work backwards from the midrib, until the fixed separator forbids a further extension; and when the sealing is added, the work certainly looks as though the tiny artificers had been taught the use of the plumb-line and the rule.

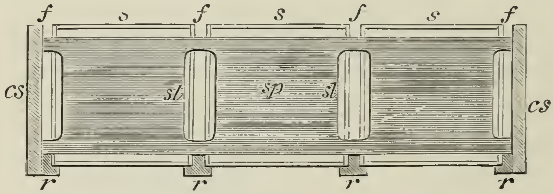


FIG. 111.—CRATE WITH SEPARATOR IN SECTION.
cs, Crate Side; *r*, *r*, Rest Rail; *s*, *s*, Sections; *sp*, Separator; *sl*, Slot; *f*, Finger Space.

It is obvious that separators (*sp*, Figs. 109 and 111), consisting of a simple strip of metal extending across the boxes (its original form) would prevent the bees passing by the side incept to the next box, as the united depth of the incepts of two boxes facing each other is needed to give the bees passage-way. To obviate this, Mr. W. H. Greer, of Tennessee, and Mr. Sambels amongst ourselves, have, independently, made exceedingly similar alterations, by introducing a slot (*sl*) opposite to the sides of the boxes, so that the freedom of communication is practically restored. This form of separator, involving another

complication, can only be cheaply made by special machinery; but that has already been provided.

We must not fail to note that the separator has an influence over the thickness of the combs, as, without it, single passage-way alone remains between those that are contiguous; while with it, passage-way of the same width is necessarily left on each side of the separator. This reduces the weight stored in any given width of section; but, what is worse, the comb is prevented from coming up flush with the edge of the box, which gives the latter objectionable prominence. The presence of four incepts, narrowing the sides, of course balances somewhat this defect, which may be overcome, even with wide-sided sections, by putting a half bee-space on to the separator itself, thus ~~destroying~~ restor the width of the comb, by holding the boxes a whole bee-space from one another. The separator holds its own because it gives always an amount of flatness and regularity, which can only very occasionally be attained without it; and this is even true, although in a less degree, of the thinner combs produced in narrow section-boxes.

The separator (*sp*, Fig. 109) may be permanently fixed to the frame, as the sections can be easily pushed out from it by arranging on a board an upright stop to guide the top bar of the frame, and then two thin pieces, standing 2in. high, the length of the frame within, and so placed that, when the frame is placed over them, separator downwards, they should just meet the top and bottom bars of the sections. Pushing the frame downwards, the separator passes between the thin pieces, but the sections remain behind, resting upon them.

It has been already pointed out that crates of sections are often completed in one part before even a start has been made in another, and that, as a rule, the central portions receive first attention. An advantage is frequently gained, therefore, by dividing the crate into three, as at Fig. 112, so that each row of sections, by being held in a separate tray, may be manipulated independently. The three parts placed closely, side by side, cover the hive top, and practically constitute a single crate. At the completion of the central tray, it can be removed, to

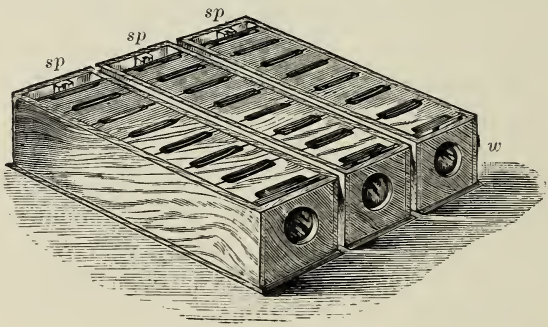


FIG. 112.—DIVIDED CRATE.
sp, Tightening Spring; *w*, Window.

make way for a set of empty boxes in a similar tray, or its place may be taken by that side tray which may be found most advanced, while the sections to be added fill the space thus created. The Rev. G. Raynor is the designer of the crate above figured, and which is much in favour. The sections are held in close contact, as in ordinary crates, by springs (*sp*), which have to be removed in order that the contained sections may be lifted

out. Windows (*w*) enable the manipulator to form a fair judgment of the progress made, so as to prevent useless disturbance of the bees.

The building of brace combs between the under sides of the sections and the tops of the frame of the hive causes some annoyance, which Mr. S. Simmins has endeavoured to prevent by arranging his sections in a crate, the bottom of which consists of narrow slats, with about ½in. interspaces; the slats standing directly on the frames, but at right angles to them, in the manner of the crossbars of a lattice. The bees thus get entrance to the sections—which have a bee-space beneath their bottom bar—through a series of openings about ½in. square. Building over those openings would bar their ingress; and between them the space is too small, and, as a consequence, brace combs are not attempted. In the same manner, when running for extracted honey, the frames of the upper storey run across those of the body-box (see Fig. 37), and come close down upon them, Mr. Simmins saying that "when one has once tried the plan, he will never again submit to a clear bee-space immediately above the brood-frames. It is there alone that comb attachments are liable to be built; but any space allowed between further super additions are not subject to this annoyance. In following out this plan of working for the past six years, I have not had a single piece of comb attached to the sections." It is impossible to secure, by any one system, the minor good points of many different ones, but it has long been my practice to so place my crates that the section combs run across

those of the brood-frames; and this certainly visibly reduces the difficulty under consideration.

A reference to page 92 *et seq.* will amuse the reader, by showing that we have been told to invert frames because honey can no longer then be stored in them, and to invert sections in order that their storing may be completed. He will, at least, be forced to admit that the explanation given in this volume applies perfectly to the practice in both cases, while it shows the absurdity of some of the theories that have been advanced. The inversion of the section at the right moment is an advantage; if performed at other times, the comb is spoiled. When the bees have built nearly to the bottom bar, inversion will cause the comb to be attached, and completed above and below; the most perfect results being obtained by fixing a second, but very narrow, strip of foundation (about two cells deep) completely along the bottom, which, after inversion, becomes the top. Corner pop-holes (see page 457) are thus absolutely prevented.

The varying stages of progress made in different sections of the same crate causes the use of the invertible form, in inexperienced hands, to be somewhat hazardous; and even Mr. Heddon has, in large part, withdrawn his advocacy. But none can do wrong by inverting solitary boxes near completion at the moment others are being removed.

The reader is referred to page 112, where an invertible crate, or rack, is described. Mr. Neighbour's form is distinctive and good. Beneath the crate is placed a loose tray (*tr*, Fig. 113), half bee-space thick, and the sections are inclosed between two exactly

similar half-cases ($\frac{1}{2}c$). Three rows of seven sections each are accommodated, and, when placed in the half-case, rest upon wooden strips (*st*) and zinc rests (*r*), which are, in section, of the form shown at *r′* (where they pass through the wood), of which B is an enlargement. These provide the second half bee-space, and so hold the sections $\frac{3}{8}$in. above the frames. Each row of sections is closed by a glass plate

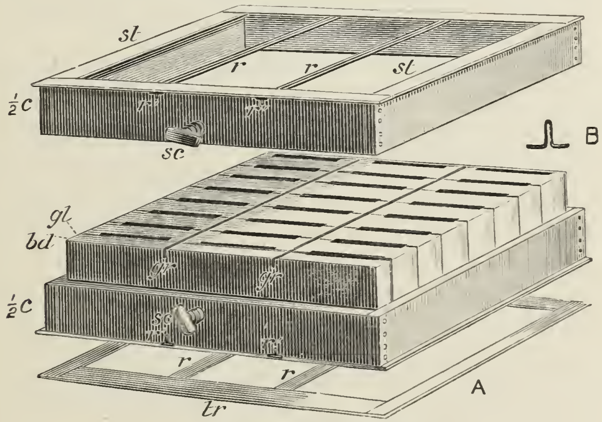


FIG. 113.—NEIGHBOUR'S INVERTIBLE CRATE.

A—*tr*, Half Bee-space Tray; $\frac{1}{2}c$, Half-case; *sc*, Screw; *bd*, Pressure Board; *gl*, Glass; *gr*, Groove; *r*, *r*, Metal Rests. B, Form of Rest in Section (larger scale).

(*gl*), against which the board (*bd*) is pressed by the action of the screw (*sc*). In actually working a single tier, but one half-case is needed, as a quilt closes the spaces between the section-boxes (page 461); but when it is desired to invert, the second half-case must be added, and the screw tightened. After the operation, the lower half-crate stands uppermost, and may be removed, if desired, to do duty in another place.

Sections, especially if well advanced, may be spoiled by the inversion of frames of old combs immediately beneath them (page 109). The spoiling is certain if these have not been built on to the bottom rails, for nibbling and paring commence, in order that the comb may be accurately filled up to the rails now above. The parts removed get interwoven with the comb and cappings of the sections, discolouring them to an extent that those who have not tried the experiment would little imagine.

Before considering the means by which the bees are to be induced to fill the sections, of which several types have passed before us, we must discuss the principles and practice of extraction—*i.e.*, of separating the honey from the comb without the destruction of the latter, as thus, commonly, the larger part of the bee-keeper's harvest is now secured.

About a decade and a half since, Herr von Hruschka effected an economy which largely increased the possible output of honey. He devised a machine known in its present form as the honey extractor, which threw, by centrifugal force, the honey from the cells, by suitably revolving the loaded combs; these were then returned to the bees, but little damaged, for repair and refilling. The previous processes of "running," "draining," and "squeezing," utterly destroyed the combs as such, leaving the bee-keeper in possession of the contained wax only, which probably would not equal in value the amount* of honey necessarily consumed by the bees in order that they

* The determination of this amount is bound about by difficulty, but the older estimates of 15lb. or 20lb. are much too high.

might secrete it (page 171, Vol. I.); but comb costs much time and labour during its modelling, and all this the extractor practically saves, while it gives the readiest possible method of clearing the combs during a rapid honey flow.

Hruschka's machine—which was, in fact, an adaptation of the then old centrifugal drying machine, and was suggested to his mind by a boy's trick in swinging round a piece of comb tied to a string—consisted of a wooden tub, within which revolved a cage comparable to a street lamp, but open at top, and bounded by stiff wire cloth. After the sealing had been shaved off (uncapping), the combs were placed against the wires, as at *co*, A, Fig. 115, and a few rapid rotations of the cage, produced by unwinding a string from the axle, as in spinning a top, sent the honey from the cells on the side of the combs remote from the centre of rotation, the operation being completed by the reversal of the sides. The extractors of to-day do not usually differ, in any marked particular, from the prototype; but some are constructed in such ignorance of first principles that these need our attention, in order that we may judge of the efficiency of any machine before investing in it, while the formulæ given may serve those making modifications in present styles of construction.

It is desirable not to make the tinned iron can (B, Fig. 115), now used, larger than necessary, yet it must permit of the rotation of the cage within; and this has often led to an undue reduction of the latter, by which the combs have been brought too near to the spindle. Let the curves *gih*, *kml* (A, Fig. 114),

represent, as seen from above, parts of a larger and smaller can, with diameters 18in. and 12in. respectively; then standard combs, rotating within the cages, will necessarily have radius-distances of which the lesser will be about one-third of the greater. Now, centrifugal force, with the same number of revolutions in a given time, varies as the distance from the centre, as shown at B, where the ball 1 (attached, like its companions, by a wire, to a revolving frame) does not move from its position, because its distance from the centre is 0;

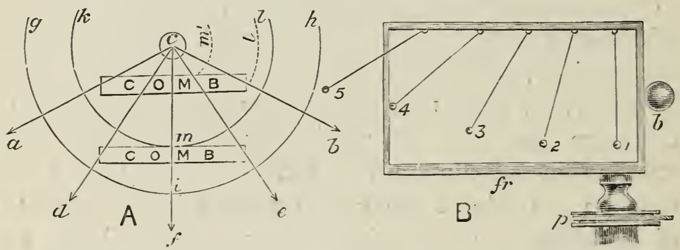


FIG. 114.—DIAGRAMS ILLUSTRATING THE PRINCIPLES OF THE EXTRACTOR.

A—*c*, Centre of Rotation, or Spindle; *ghi*, *klm*, Cans; *ca*, *cb*, &c., Lines of Force. B, Apparatus to prove that Centrifugal Force varies as the Radius-distance—*p*, Pulley; *fr*, Frame in Rotation; *b*, Balance-weight; 1, 2, 3, 4, 5, Weights Rotating.

whereas 2, 3, 4 and 5 fly off with constantly increasing energy. It therefore follows that, with the same velocity given to the spindle, the honey in the larger can will fly off with three times the energy that it will in the smaller.

The question arises: Is the smaller machine necessarily less powerful than the larger? By no means: increased rapidity of rotation will immediately compensate for lack of size, and that, too, with an actual economy of driving power (as explained by the

foot-notes,* in which the mathematics of the question is given, as too complex for the general reader); but a mischief arises, respecting which misconception prevails. The lines of centrifugal force run, as the name implies, directly from the centre—as *ca*, *cb*, *cd*, *ce*, *cf*; and so the energy generated tends, in the middle of the comb (*m*), to throw out the honey direct; while in *ca*, the larger part of the energy is expended in driving it against the side of the cell. As the lines *ca*, *cb*, playing upon the comb in the smaller can, are so extremely divergent, the rending strain, tending to drag the upper *from* the lower part of the comb, is so great that ere all the honey can be extracted rupture is an almost inevitable result. To say that all the honey is not extracted, as a consequence of small radius-distance (as one writer has done), is a palpable error; for the top and bottom of the comb (the comb standing sideways) have more than twice the radius-distance of its middle (see *t* and *m′*), so that the loss through the obliquity of the forces at the greater dis-

* α. Centrifugal force equals the square of the velocity divided by the radius distance $= \frac{V^2}{r}$.

β. The energy required is in the ratio of the squares of the velocities. If two systems have their radii as 1 : 4, and their centrifugal pressures equal for equal masses, then

$$\frac{V_1{}^2}{r} = \frac{V_2{}^2}{4\,r}, \text{ and } 4\,V_1{}^2 = V_2{}^2;$$

therefore

$$V_1{}^2 : V_2{}^2 :: 1 : 4;$$

i.e., (β) the energy demanded is in the ratio of the radius-distances. This points to the greatest possible reduction of the radius-distance; but as the latter decreases, the waste of energy from angular displacement, producing pressure on the cell side, increases, and these balance one another, for standard frames, at about 6in. For deeper frames, the radius distance should be greater, Langstroth frames requiring 7¼in.

tance is exactly compensated by their greater energy; therefore, it is as demonstrable* as Euclid's propositions that the honey will be equally thrown out all over the face of the comb, if this only stand perpendicularly, whatever the radius-distance may be, but that the tendency to rupture will increase as the distance is decreased. Calculation and experience alike point to a radius-distance of about 6in., for the centre of combs of standard size, as giving the best results for the energy expended.

From what has been said, the error of giving the cage a taper form is evident. Here the cells at the lower part of the cage are practically in a small machine, and at the upper in a larger; demanding the impossible condition that more rotations be made below than above. It follows, therefore, that, to extract at the lower part of the cage, excessive strain must be put upon the comb at the upper. The taper form has no excuse, except the fancy that the combs lean safely against the cage while preparation is made for rotation; but since the cells have been uncapped, the whole adheres quite sufficiently when brought up against a perpendicular wire cloth; and, indeed, this close bringing up of the comb is most important, or else, when the handle is turned, the comb will "hug" the netting, and possibly drag itself from the frame in doing so.

* Diverging lines from the centre (*c*), meeting a comb, measure the radius-distance of its several parts, and so, in accordance with the principles already given, represent the centrifugal force of each part in direction and magnitude. Resolving these lines into two components—one at right angles to the cell sides, tending to split the comb, and the other in the direction of the cells, tending to throw out the honey—we find the latter all exactly equal, proving that the extracting energy is alike throughout the face of the comb.

Few are aware of the tremendous centrifugal force accompanying high velocities, its increase being in the ratio of the square of the rate. Combs, always relatively tender, may be, in consequence, extracted without damage, while, at an apparently slightly greater pace, they are wrecked. The subjoined Table* will make this clear. The highest rate given is much beyond the endurance of any but the very hardest combs, and is never required, thick honey leaving, even in a cool atmosphere, when the pressure equals four times or five times the weight, *i.e.*, the 20lbs. or 25lbs. of the Table; but I have seen geared machines most needlessly driven much beyond

* TABLE OF PRESSURES made by Comb of 5lb. weight against wire net of Extractor working at 6in. from centre of spindle.

Pressure.		Velocity per sec. ft. in.		Revolutions per Minute.
1oz.	....	0 5⅜	....	8·56
1lb.	....	1 9½	....	34·26
5lb.	....	4 0⅛	....	76·63
10lb.	....	5 8⅛	....	108·37
15lb.	....	6 11⅜	....	132·72
20lb.	....	8 0¼	....	153·26
25lb.	....	8 11⅝	....	171·34
30lb.	....	9 9⅞	....	187·69
35lb.	....	10 7⅜	....	202·73
40lb.	....	11 4¼	....	216·74
45lb.	....	12 0⅝	....	229·67
50lb.	....	12 8⅜	....	242·31

The pressures and velocities per second corresponding to these revolutions per minute may be found for any other radius-distance by multiplying the amounts in the first or second column respectively by that radius-distance in inches, and dividing by 6. Similarly, the numbers of the third column, multiplied by $\sqrt{6}$, and divided by $\sqrt{}$ any radius-distance in inches, will give the revolutions required by that radius-distance to sustain the pressures of the first column.

200 revolutions per minute. With 6in. or more radius-distance, gearing is not required, as sufficient pace—which should be kept at the lowest that will accomplish the work—can be reached without it. Then brood—even drone-brood, should such be found in the comb—will not be displaced; but brood should only under exceptional circumstances find its way into the extractor. Care should be taken to place combs of nearly equal weight on each side of the cage, for the latter, according to a law of dynamics, will endeavour to revolve around its own centre of gravity. The effect of this will not be felt until the combs revolve quickly, when their increased pressure, if they be badly balanced, will set the can rocking in an almost uncontrollable manner.

The pressure on the wire net is of necessity so considerable, that that of ordinary make is driven into a concave form, which the comb fills, and is, in consequence, often so bent that it cracks and, after its return to the bees, breaks. Mr. Meadows has remedied this grave fault by a simple but effective device. Behind the wire net (*wn*, A and C, Fig. 115) he fixes, edgeways, strips of tinned iron (*wb*), which, like the joists of a floor, give to the net perfect rigidity. This plan is a patent, but surely all makers can do something towards securing greater stiffness than is usual.

Not only does the *honey* fly by centrifugal force, but the air around the comb made rapidly to revolve, also flies off, occasioning a strong and prejudicially cooling air current. Mr. S. J. Baldwin was the first to remove this disadvantage, by placing the comb within

a bottomless, revolving cylinder, so that the air and comb revolved together, becoming relatively still. In the Raynor, the wire net and the webbings are similarly surrounded by a casing of tinned iron (*oc*, C), by which not only draught is checked, but the honey, instead of bespattering the large can to the top, flies

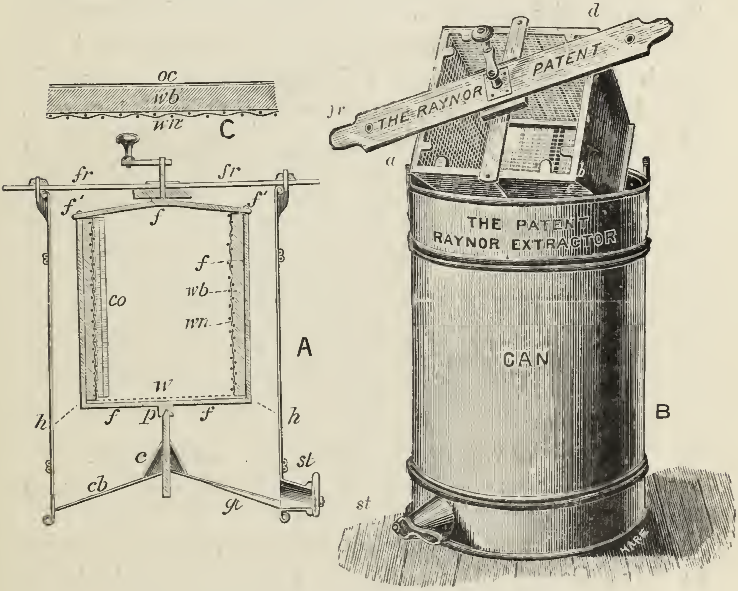


FIG. 115.—THE RAYNOR EXTRACTOR, WITH DETAILS.

A, Section of Extractor—*fr*, Fixing Rail; *f, f*, Frame for Cage; *wb*, Metal Webbing; *wn*, Wire Netting; *co*, Comb; *w*, Wire Bottom; *p*, Pivot; *c*, Stiffening Cone; *cb*, Coned Bottom; *gt*, Gutter; *st*, Syrup Tap. B, Extractor with Cage displaced. C, Perpendicular Section of Side of Cage Enlarged —*oc*, Outer Casing; other Letterings as before.

off at the lower edge of the cage (*h*), and is saved from waste.

In the Raynor the combs can also be extracted on both sides, without removal from the can—a good

point, but one the importance of which is being exaggerated, for the time required in raising, turning, and re-inserting a comb in a roomy cage is exceedingly short. The operation of turning in the Raynor is managed thus: If one of the two combs lies along the line *a b*, B, the ear of the frame extends upwards, at the angle *b*. The outer cells having been emptied, the ear is revolved in the fingers until the comb lies along the line *c d*, when, as the outer side has become the inner, the operation will be completed by again rotating the cage. The reversal of

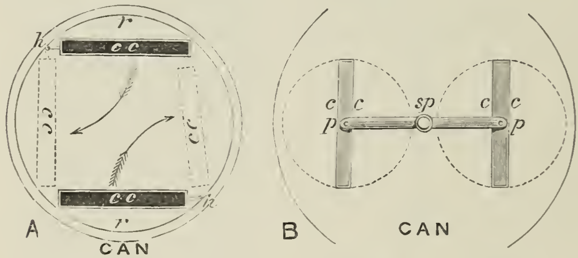


FIG. 116.—TOP VIEW OF EXTRACTORS ON MR. COWAN'S SYSTEM.

A, Improved Rapid—*cc*, Comb-cases; *h*, Hinge; *r*, *r*, Revolving Ring of Tinned Iron. B, Automatic—*sp*, Spindle; *p*, *p*, Pivots; *cc*, *cc*, Comb-cases.

the combs without removal constitutes the main feature in Mr. Cowan's extractors. In the "Rapid," the combs are placed in two baskets, or cases, about 2in. wide, and wired on both sides. These are hung, like doors, at the angles of a framework cage, and can be swung round so as to put either side of the comb outwards, which can, in consequence, be freed of honey from both sides without removal. This form is much improved by substituting a ring of metal (*r*, A, Fig. 116) for the framework cage; draught is reduced, and the

honey less scattered. The comb-cases (*cc*) are hinged at *h*, and pass into their new positions as the arrows indicate. To this plan it is objected that the saving in time is inappreciable, if any, and that the double motion of the revolving cage and the hinged cases gives the whole an undesirable loose-jointedness, but the form of the cages makes them handy for extracting from loose pieces of comb.

The "Automatic" (B), so called because the combs reverse upon the stopping of the handle, has two racks and stops, permitting the comb-cases (*cc*, *cc*) to take a half-rotation upon the pivots (*p*, *p*). The insertion of the unsealed combs is an awkward affair, as they cannot be slipped in from above, but at the side, which is removable, but needs fixing, for an obvious reason. Turning the handle in one direction extracts one side; reversing the handle reverses the combs, and extracts the other; but this trifling advantage is far outweighed by the mess and bother of inserting and releasing the combs at the beginning and end of the operation. At its birth it was highly eulogised;* in justice, therefore, to my readers, I must point out that it needs a very large can in proportion to the radius-distance it affords. In Figs. A and B we get a comparison, as here the radius-distances are equal. It is more complex and expensive than other extractors; very messy and wasteful, as the cages get coated through and through, and the large can covered within. The objectionable draught is here greater than in any other, while, in point of

* Cowan's "Bee-keeper's Guide-book," page 69.

time required, it could not hold its own with any of the usual types.

Machines have been introduced to extract from four to six combs at once; these appeal only to the operator on a large scale, who will be able to judge for himself of their suitability. They are, necessarily, not portable, but they save labour when the uncapping can be performed with sufficient quickness to keep them going.

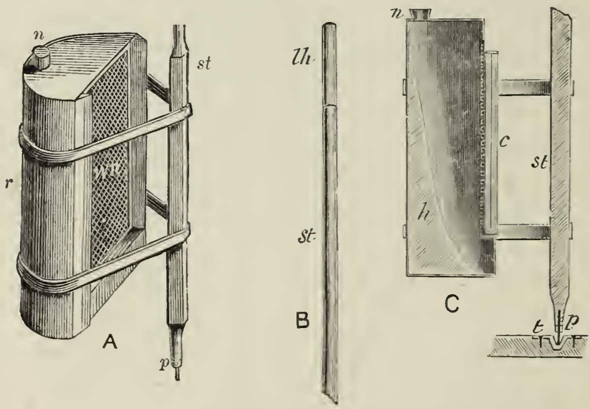


FIG. 117.—ABBOTT'S SINGLE-COMB EXTRACTOR.

A and B, Extractor (Little Wonder)—*n*, Neck for Emptying Honey; *wn*, Wire Net; *r*, Reservoir; *st*, Stick; *p*, Iron Pin; *lh*, Loose Handle. C, Section—*h*, Honey; *t*, Thimble; *c*, Comb; other Letterings as before.

About twelve years since, Mr. Abbott introduced a cheap and handy appliance, "The Little Wonder," which has done excellent service, and is sufficient where the stocks are few and economy needs studying. With it one comb only can be operated upon at a time. This, when ready, is placed against the wire net (*wn*, A, Fig. 117), the iron pin (*p*), at the end of the upright stick (*st*), being firmly socketed into

a board, or, better, a permanent iron thimble (*t*, C). The whole now receives a whirling motion, by a sway of the hand, which grasps the loose handle (*lh*, B). As the velocity increases, the honey (*h*, C) is thrown out into the side can, where centrifugal force keeps it heaped up. It may from time to time be drawn off from the neck (*n*). For portability nothing can equal this little extractor, which does its work perfectly, although at a rather heavy expenditure of labour, as the honey has to be kept going together with the comb; it is, in the hands of the novice, a little likely to fly from its socket; the iron thimble is therefore strongly recommended.

Extractors, and all vessels used to hold syrup, should under no circumstances be made of galvanised (zinc-coated) iron (page 382), as the zinc and iron form a galvanic* couple favouring an attack by the acid of the honey. Sugar also has a reducing action, and is capable of replacing five atoms of its hydrogen by the metal, forming a poisonous compound, which in large quantity in the honey is dangerous, and in small amount is abolutely fatal to delicate flavour. Zinc vessels are nearly equally unsuitable, and syrup kept in such, especially if it be thin, is liable to become so impregnated as to poison bees fed with it. I have had such cases under microscopic examination. The can may with advantage have a sufficient space beneath the cage to hold 40lb. or 50lb.† before emptying becomes necessary; and if the material be tinned iron,

* F. Cheshire, in *British Bee-keepers' Journal*, Vol. XIV., pages 532, 573.

† An 18in. can holds 12lb. for every inch of its depth.

no damage arises from leaving the honey within for any period convenience may dictate.

The cages are usually arranged to hold standard frames, but it is often desirable to extract from unfinished sections, for which no smaller machine is required, as these can be conveniently arranged on a hanger having a shelf-like stage wide enough to carry them; but since the newly-built combs are tender, a little artifice is essential. First, partially extract from one side, rotating slowly. The whole weight of the honey on the cells of the inner side

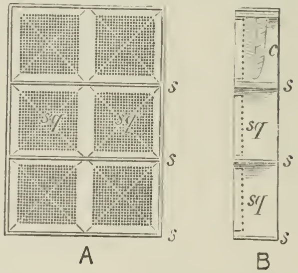


FIG. 118.—FRAME IN WHICH TO EXTRACT SECTIONS (Scale, $\frac{1}{12}$).

A—*s*, *s*, *s*, Shelves; *sq*, *sq*, Squares of Wire Cloth. B, Section of A—*c*, Comb; other Letterings as before.

will tend to push the comb from the section, but with slight pressure only, as the Table (page 473) will show. Now turn the face, and throw out all the honey, once more reverse, and complete. A difficulty exists, however, in that the combs, when unfinished, are much narrower than the boxes, so that the former receive no support from the wire cloth. This I obviate by a wooden frame 2in. wide (A, Fig. 118) about standard size, carrying shelves (*s*, *s*, *s*), upon which six sections, $4\frac{1}{2}$in. square, can stand. At the

back run cross wires, upon which are soldered squares (*sq*) of wire cloth, the edges of which have been turned back so that the squares stand up about ½in., as seen in the section B. They are so small that they need no stiffening. The section box runs back, and brings the half-thickened comb (*c*) into contact with the wire, so that, as the frame stands within the revolving cage, it can be extracted in safety. Broken pieces of comb may be stood against the wire net of the extractor, but a comb-basket is frequently useful. It is simply two frames of coarse wire cloth, hinged together at about the thickness of natural comb.

The removal of the sealing (uncapping) is accomplished by a knife, the handle of which is raised above the general level of the blade, like that of a trowel. The sealing has, all but invariably, behind it a film of air* (page 174, Vol. I.), and the object should be to cut through this, and so, as far as possible, escape actual contact with the honey, the viscosity of which so holds the blade, if wide and flat, that good work is extremely difficult. Thin-bladed knives, turned up near the end, to permit of cutting into hollows, are frequently used, but the Bingham-Hetherington Knife (A, Fig. 119), is justly the favourite. The stout blade is so bevelled (C) that it must be kept up from the comb, whereby the "cling" is greatly reduced. The edge should be keen, and the hollow front (*f*) permits of sharpening on a hone. It

* This film of air in part exists in sealing by Cyprian and other eastern bees, as may be seen by uncapping under water; but in the work of Blacks and Carniolans it is general over the face of the cell, and adds much to the beauty of the comb.

is helpful to use the knife hot; the best plan being to have a pair—one standing in heated water while the other is in hand. The water should not boil, or the wax will be melted and adhere to the knife, delaying the operation. Some advocate making the cut downwards, with a drawing movement, allowing gravity to curl the cappings away from the knife; I, and most others, prefer to make it upwards (as at B), turning the cappings into a receptacle, in

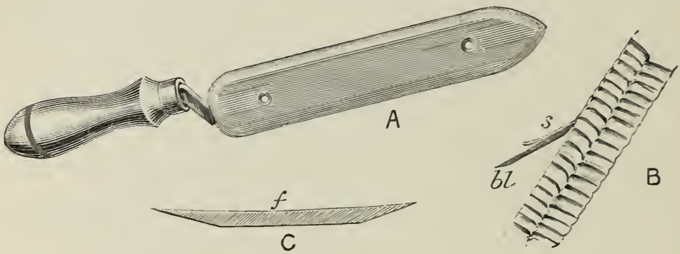


FIG. 119.—UNCAPPING-KNIFE AND DETAILS.
A, Knife seen from beneath. B, Section of Comb and Knife (Scale, ¼)—*s*, Sealing *bl*, Blade. C, Section of Blade.

which is fixed on edge a thin piece of soft wood, as a scraper for the knife.

Efforts are being made to produce a machine which shall perform the tedious work of uncapping. Mr. Simmins uses serrated knives, acting simultaneously upon the two faces of the comb, which passes down between. Flat finishing is essential, and this is achieved by using, in an upper storey, thin wooden dividers (separators), with 1⅝in. full interspaces. The combs in these are capped so evenly that the knives catch every cell.

Mr. Hooker has recently patented an uncapping

machine (Fig. 120), which needs but little explanation. The frame carrying the comb is clamped by screws (*s*, *s*) in an iron frame (*i.f.*), in which it is held centrally by a stop. The iron frame runs on a V-shaped guide (*v*, *v*), and is pushed by the handle (*h*) against the knife (*k*), and a similar one on its back face attached to *kh*. A drawing cut is made as the knives stand at the low angle of 20°, while the blades are set slightly inclined towards the comb at the edge,

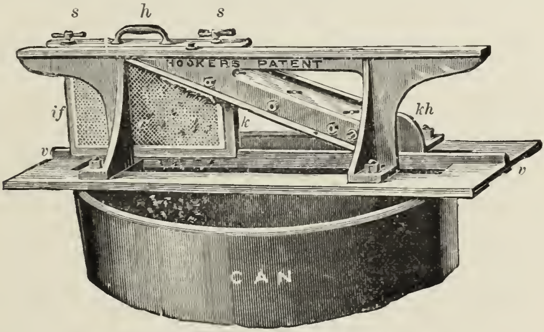


FIG. 120.—HOOKER'S UNCAPPING MACHINE.

v, *v*, V-shaped Guide; *i.f.*, Iron Frame; *c*, Comb; *k*, Knife; *s*, *s*, Screw Clamps; *h*, Handle; *kh*, Knife-holder.

so as to clear behind and prevent clinging. Adjustment can be made for variation in comb-thickness.

Other forms are also before the bee-keeping world, one of much promise having a perpendicular shaft covered with projecting points. This, driven by a wheel and crank, revolves rapidly, uncapping the comb, which is pushed past it, guided by a groove. Simple experiments show that a very rapid movement uncaps without any tearing of the cell walls, and it is worth remembrance that each time a comb

is uncapped it is improved, so far as evenness is concerned, for the next operation.

The general public appear to foster a vague notion that comb honey is necessarily unsophisticated, while extracted may, at least, be regarded as a body whose purity is not proven, for the beauty of the comb itself would hardly account for the great disparity in the prices of the two, although the disparity is quite justified by the difference in the cost of production. Wax is not human food, and when the errors just expressed have passed away, and the wretched, bottled imitations of honey, now well-nigh driven from the market, have been forgotten, extracted honey will be more highly valued than at present. Every effort should be made to secure it in the most palatable form, and to that end all should abandon the doubtful policy of extracting from combs containing brood, for the thought of it is, at least, not appetising, and proper management of the brood-nest makes the practice needless. The finest samples of extracted honey, if obtained from the right flora, come from fully-sealed combs in which breeding has not taken place, for here the *débris* consists of wax alone, specifically lighter than honey, and therefore soon at the top for removal. If scrupulous care has been taken in cleansing the extractor from dust and other matters, this first grade stuff will hardly need straining, standing and skimming being sufficient. An ideal sample would have a delicate but characteristic aroma, a rich flavour, leaving a distinct impression on the back of the palate, and would be of a straw or pale amber colour. It should possess perfect clearness, and, as

distinct from clearness, brightness, due to a high refractive index, with density almost amounting to toughness, so that the air beneath the cork should rise very slowly through the mass upon the inversion of the bottle. Any tendency towards a muddy-brown in colour, especially if associated with a sickly odour, is a grave fault, pointing to an admixture of aphide honey (see page 270, Vol. I.). No sample should be bottled too quickly after extraction, for the sharp splashing in the extractor loads it with minute air-bubbles, which at first impart a cloudy character, and these, rising subsequently, form an unsightly froth, which long remains.

Honey got from old combs, although possibly of high quality, yet contains multitudes of tiny particles more or less damaging to the colour; and should these be associated with many distributed pollen grains, perfect brightness will never be attained. The particles, scarcely rising or sinking, can only be got rid of by careful and slow straining through flannel,* which should be made into a deep, conical bag, to be, after most careful rinsing, filled with honey while still wet. If, after straining, the honey is yet cloudy, it may be kept in bulk some months in a warm place, to be then syphoned out with a wide tube, taking care that the submerged leg is about the middle of the mass. As most of the foreign matter rises, results nearly as good will be obtained by running out below from a syrup-tap, or honey-gate, as our American cousins delight to call it.

* Running through muslin, or straining-cloth, is sufficient for all ordinary purposes.

The density of honey is an important point, and on that account I just now enforced the necessity of all the cells being sealed before extraction. If our object is quantity, and not to win in a quality competition, it may often be a great economy to extract so soon as the cells are well filled. The comparatively watery honey thus obtained is somewhat liable to ferment and become acid. This may be avoided by exposing it, not to dust, but to a warm, dry atmosphere. As the top layer of honey loses its excess of water, it sinks and brings the thinnest again to the surface.

The sinking of the densest portion will allow honey in deep vessels to grade itself, and although, by liquid diffusion, the density will at length become equal, the process is exceedingly slow. A bottle of honey of high quality, which had travelled from Higher Bebington, Cheshire, to the Exhibition, Kensington, and was then returned North, came back to the Author with the refractive indices of different parts unlike. The journeying had not absolutely mixed it.

Honey kept at a low temperature (or, rather, if not kept at a high temperature) candies—*i.e.*, some of its sugar crystallises out. The crystals hold the liquid parts between their meshes, so solidifying the whole that it may be carried in paper like butter. The disposition to candy varies with the source whence the honey has been obtained, some specimens quickly setting almost into a block. Candying is no proof of purity, yet it is a presumption in favour of it, since candying spoils the appearance of the honey, while it may easily be prevented by adulteration, glucose

containing dextrose having frequently been added in bygone days with this very object. The candying or granulation can be removed by heating, and the best plan is the water-bath—*i.e.*, a double vessel, like a glue-pot, the outer one containing boiling water, the inner the substance to be heated. In this way the honey cannot be appreciably injured; from which it follows that new comb honey, in the absence of an extractor, may be melted down. Carry the heating only far enough to thoroughly liquefy the wax, and then allow to cool: if the vessel has taper sides, the wax can be most readily removed.

The beautiful, rich-coloured, and highly-flavoured honey obtained from heather, the pride of the Scotch hills, is, for the two or three days following gathering, extremely limpid, dropping on the slightest jar from the comb, if the latter be held in a horizontal position; yet it becomes so gelatinous when ripened that the contents of a single cell, if successfully removed, will retain its hexagonal figure for some time, and this apparently from the presence of one or other of the pectose group of bodies allied to arabine. The extractor is now unable to dislodge it, and Mr. Raitt, whose name is so closely associated with heather honey, has met the case by devising the honey press (Fig. 121), respecting which he has favoured the Author with the following particulars. The usual method hitherto employed in getting drained heather honey has been by mashing the combs, and then expressing the honey by means of strainer cloth; and to do so with any degree of success the broken-up combs had to be heated. Even then the process was both uncleanly

and partially ineffectual, much honey remaining in the cloth. Previous attempts at a press were on the principle of dealing with broken-up combs, by which a good deal of the pollen became mixed with the honey.

The receiver occupying the middle of the stout

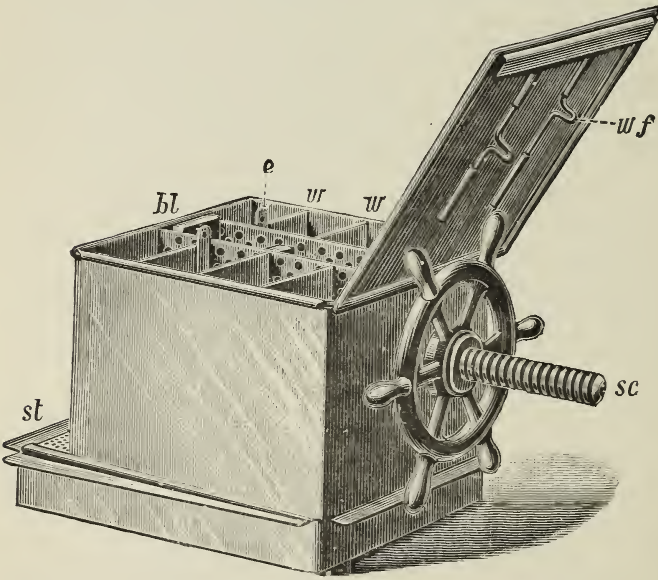


FIG. 121.—THE RAITT HONEY PRESS.
st, Strainer; *bl*, Block; *w*, *w*, Webbing; *wf*, Wire Fastening; *sc*, Screw; *e*, Eye to receive Wire.

block-tin box, open in Fig. 121, is a perforated chamber strongly backed by webbings (*w*, *w*). It is wide enough to take only a single comb on edge ($1\frac{3}{4}$in.). The lid being shut, and the wire fastenings (*wf*) passed through the eyes (*e*), the pressure is applied by the powerful screw (*sc*), which slowly drives forward a

piston (the width and depth of the box). This, approaching the block (*bl*), so presses the cell walls towards one another as to cause the honey to flow only from their mouths, the cappings giving way under the induced pressure, while the cell walls shut together like the fingers of an empty glove, retaining the pollen, which is thus, as it were, shut in. The honey, passing the perforations in the receiver, falls between the webbings into the strainer below. When the comb has been crushed hard against the block (*bl*), the screw is reversed a turn, and the block, or gate, lifted out, exposing an opening in the side of the box the size of the piston, which is again advanced until the wax and *débris* adhering to it in a flattened cake protrude beyond the receiver, and are easily removed. The perforated metal (*st*) is meant to allow any drip from the gate to find its way into the interior of the rim on which the press stands, and which should be fitted into a stool or table to give steadiness, and to which the cheese-cloth strainer may be hung. Mr. Raitt explains that large combs generally contain so much pollen near their upper edges that its resistance would prevent the lower cells from being sufficiently pressed; he, therefore, prefers to operate upon pieces about half standard size, and such his press was designed to accommodate. He adds that "the honey obtained by it, even from brood-combs, has been equal to the finest samples he ever drained from sections."

Surplus, as all must admit, whether in the form of comb or extracted honey, is unobtainable in large amount without a copious flow of nectar, and, at its

opening, abundance of bees, respecting which see pages 413 *et seq.* If to these two essentials we add the movable-comb system, and a hive of sufficient capacity, it is hardly possible that we can escape a good harvest awaiting the extractor; but with all these conditions acting together, it is easy to fail dismally in reference to comb honey, heavy yields of which are only won by skill and well-timed attention on the part of the bee-master. Extracted honey, therefore, logically receives our first attention; yet even here the deepest knowledge alone can accomplish the best results.

In working for extracted honey with long hives, empty combs may obviously be placed either behind or on each side of the brood-nest, to be removed when full; others then occupying their places; but in either position, only very few combs can be added with advantage at one time. Here, in addition, the honey ripens slowly, and sealing is sluggish, so that our comparatively short season is gone before much can be accomplished. But with the tiering or storifying system, which has proved itself unequalled, the heat of the brood-nest rises easily through any workable number of storeys, quickening every operation, from the secretion of wax to the last touch which covers the honey from view; while, under usual conditions, the bee-keeper can add or subtract a whole storey at a time, both economising his labour and reducing interruption to the bees; and, furthermore, he may, if he so please, consult his convenience by leaving in position the honey already gathered and sealed until the rush of work of the mid-season is over. The broad lines of

the storifying system are quickly learnt, but the details allow of almost limitless variation; these variations frequently being dictated by special but transient circumstances.

Where standard frames are used, the brood-nest occupies, under ordinary circumstances, a single storey only, and to this, at the opening of the harvest or just before it, the bees being already strong, another may be added containing a set of combs, or frames fitted with foundation. But circumstances alter cases, and the problem is by no means so simple as would at first appear, for arguments are adducible in favour of making the addition both above and below the brood-nest. For the latter, or nadiring method, it may be urged that as honey is brought in it will take its natural place above as bees hatch out, while the brood-nest will be gradually forced downwards, as happens normally with undisturbed colonies during the accumulation of wealth in summer, necessitating the descent of the wax-workers, queen, and nurses to occupy the storey below; that, although the hive has been doubled in capacity at one stroke, no peril from chill arises, the bees passing down only as they are able to occupy new territory; that the danger from swarming is, for the time at least removed, and that the bee-keeper may, the honey flow continuing, and the weather being warm, add another box of combs; and that, in this manner, the combs below (foundation having been given) will reach completion slowly—not at all if those in the top tier be replaced as they are capped by others that have passed through the extractor, whereby the swarming impulse is most un-

likely to present itself. But, on the other hand, it is clear that the brood-combs will not be quite free for honey for twenty-one days after nadiring even if the queen lays no more in them, and that extraction cannot, therefore, commence for several weeks ; while in the extractor, also, the newly-gathered pollen of the brood-combs may in part leave with the honey, giving to the latter a cloudy appearance.

The plan of adding the second box above is admittedly not free from dangers, but, these being overpassed, it gives superior results, and hence would be adopted by the expert in honey-production as his experience enables him, by first getting his brood-nest almost wholly filled with eggs and larvæ, to secure not only a big population, but *future* space for the queen to lay, as these are in succession converted into bees; while, by the movements of the foragers, he can gauge the flow of nectar and give new storage room just in front of that which is required in addition to ventilation and shading, and thereby keep swarming in abeyance. If he adopt nadiring, it would be early in the season, during a moderate in-gathering, to be followed, in his calculations, by a great flow, at the advent of which another set of combs would be placed on the top. For, if placed between, they would most probably be at once accepted by the queen as an invitation to unlimited egg-laying, and not only would brood be formed where honey was desired, but a very large part of the energies of the population would be absorbed in brooding, feeding, and sealing larvæ, to become gatherers only when gathering is nearly or totally at an end. This question of the limitation of the production of brood

is most important, especially in relation to comb honey.

To return to our stock, above which, let us suppose, some days previously, a storey of combs had been placed; as these are getting in large part filled, while the bees are gaining strength, a third tier should be added, and, according to usual practice, beneath the top box, in order that the latter may be carried off when ready for appropriation; but Mr. Raitt very wisely urges that, where excluder zinc is not used, the difficulty just now mentioned is likely to meet us by the queen giving her attention to the alluring combs. He therefore places these above, far away from the haunts of the queen, until partly filled, and then interchanges the two top boxes, the upper of which will soon be completed, to be then taken away bodily, to make room for one carrying empty combs as before.

The determination of the correct moment for adding a new tier needs experience. The condition of the upper box can be pretty accurately estimated by turning back the corner of the quilt, and looking at the outside face of the outside comb. This will remain unsealed longer than the others. Should white capping be seen at its end, the time for removal cannot be distant; and if the bees are working energetically, especially if the weather be very hot, no time should be lost in increasing accommodation: for it must not be forgotten that, as honey is gathered, the space within is constantly reduced, while a box of absolutely completed combs is generally well-nigh vacated by the bees. In adding new combs, the rule will always be followed of spacing a full $1\frac{1}{2}$in.

(supers) for honey, and a full $1\frac{1}{4}$in. (nadirs) for brood.

Of course, the process of adding empty and removing full tiers is limited by season and district, as well as the capabilities of the stock, and, these all being good, a fourth box of standards may be required; but it is desirable, while securing to the bees abundant cells in which to deposit their gains, to make the accommodation no larger than this demands, or loss arises in many ways, while the combs at the close of the gathering, remain only partially filled. In working for comb honey, this would be disastrous—with extracted, it is not important, and for the following reason: Bees never seal cells until they are full, and so half-filled ones remain open when the honey yield drops to current consumption; but, after three or four days, this unsealed honey is as dense as the rest, and may be thrown out by the extractor without the least detriment to the general crop.

In working thus for extracted honey, it is not room simply that is given, but comb with empty cells; so that the bees drawn away to the fields by breezes redolent with nectar, can, at their return, at once discharge their load, and start unhindered for another, without depriving their queen of the use of the brood-nest, by which the strongest predisposition to swarming is avoided; but, in addition, our queens should be young (see page 277), and, unless the hives have very non-conductive walls, they ought to be carefully shaded, while the entrances should provide abundant ventilation. My own run, by the removal of the sliding door, 16in. by $\frac{5}{8}$in.—none too much; lifting the hive from

the floor-board by shallow blocks, so that ventilation is secured all round, being often desirable.

Mr. Raitt,* whose advocacy for simplicity is always of the wiser sort, manages his entrances in such an ingenious way that I wonder it has not been largely adopted. It is, of course, necessary in tiering that the doorway remain in the lowest box, but in that one only. He rabbets both the sides and front and back of his hives, which are 14½in. square within, so that the frames may hang either way. The sides are double, the front and back single; but when the frames run across the entrance, for wintering, dummies front and back practically make the hive double all round. For the working season the frames run from front to rear, to secure more perfect ventilation; but the point lies in this—that the front, which is of equal depth with the sides and back, on nailing together, is kept up ⅜in., leaving a doorway below, while its upper edge stands up from the sides so as to close the doorway of the exactly similar second storey, when that is placed upon it; and so on in every tier, the lowest doorway being infallibly open, while all above must be infallibly closed. The rabbet of the front is necessarily made ⅜in. deeper than that of the back, so as to bring the bearings of the ears of the frames to one level. These body boxes also act as super covers when working for comb honey.

Doubling, as a favourite practice with many, demands some notice; it consists in removing all the combs from a strong stock, and placing them, filled as they are with

* *Bee-keepers' Record*, Feb. 15th, 1885, page 21.

brood, in a second storey over another colony. The swarm formed may be advantageously utilised by being run for comb honey over a contracted brood-nest, as hereafter explained. With the doubled stock, the progeny of the two queens will give, in a week or so, an immense gathering population, filling the cells of the upper storey as vacated. The process should antedate by some days, at least, an expected honey flow, at the beginning of which a third storey should be added. In good honey districts, in a favourable season, a fourth tier will be required, especially if the top one remain on for complete sealing, so that it may be removed bodily instead of each comb as ready.

Doubling, with every form of condensing that will secure gigantic stocks, has its advantages—*e.g.*, 60,000 bees will give more than double the result in surplus of 30,000, because temperature with a large number is regulated and sustained with less individual effort than with a smaller, and also because the 60,000 have but one queen instead of two, by which the demand upon their energies in brood-tending is relatively reduced. A loss, however, accompanies the gain—the larger hive and denser throng impede movement and delay work; and careful experiments seem to indicate that after 12lb. of bees have been heaped together, the loss is greater than the advantage. The defect of doubling lies in the presence of brood in the upper storey occasioning delay, as already pointed out—a serious disadvantage with our short season, but relatively unimportant in America, where the practice is very usually followed.

In dealing with those stocks which, from any cause

save that of disease, have failed in rising to profitable proportions, some form of condensation is of the very highest importance, and the novice must not think that a strange thing has happened to him if *all* his stocks are not first class; for it is the common experience of even the greatest adepts, who sometimes, in describing their remarkable doings with a few colonies, mislead by failing to note how little they have done with others. Two poor ones (see pages 432, 437) have two or three weeks of progress put into them by union, and so possibly save the harvest. A fair one, being filled up with brood from a second like to itself, which henceforward is a nucleus for queen-raising, becomes so quickly strong that it enters the lists as a honey stock. It by no means follows that frames of brood given should remain; and, indeed, in working for comb honey, it is often most desirable to add such, and, after the bees are hatched, remove them, as the less room the colony has outside its sections, short of driving it to swarming, the better.

Storifying with standard frames is not so absolutely manageable as with those that are shallower. Even the preparatory operation of spreading the brood, when the nest extends to two boxes, is more quickly done by horizontal than perpendicular division. The nest is very rarely centrally placed, and then a half-rotation of one of the boxes spreads without risk. Interchanging (page 94) cuts the theoretically globular collection of brood horizontally, and the circumference is brought to the centre, while the widest part of the nest takes the top and bottom. Honey is now inevitably removed

from the middle, and cannot be replaced above, for brood already holds possession. In all subsequent work, the shallower frame appears to the Author to have every way the advantage, while he has proved it to be superior for wintering purposes. Mr. Broughton Carr, whose splendid extracted honey is well known, is an earnest advocate of a shallow frame, which he has so cleverly championed, in the *British Bee-keepers' Record*, December, 1886, and January, 1887, that all would do well to read his remarks. His narrow tiers, 6in. deep, carry between thirty and forty pounds of honey. Shallower combs are more readily sealed, the different grades of honey depending upon their sources are more easily kept distinct, uncapping is more readily performed, and in extracting from virgin combs (of which more presently), fracture is less likely. Those using standard frames may adopt without prejudice tiering bodies of a less depth.

Smoke and carbolic acid are both of service in interchanging and giving new tiers, as well as in enabling us to harvest the honey. When the first upper storey is to be added, a cloth wrung out from the carbolic mixture (page 19), or common carbolic shaken up with water, and placed over the hive from which the quilt has just been lifted, sends the bees below; to effect this object we may adopt Mr. Raitt's plan of using stiff paper (I prefer loosely-made brown), smeared with crude carbolic acid. He says:* "On raising the paper, gradually beginning at one side, we are able, without interruption from a single bee, to pass a scraper over each top bar, removing all propolis and bits of

* *Bee-keepers' Record*, July 1st, 1887, page 126.

comb. The paper is again dropped for a moment, and on again raising it we are enabled to slip in our excluder without trouble. The paper is now laid aside, and the upper storey, with all its empty combs arranged, is at once set in place." In inserting a storey between others, paper smeared on both sides is used. The storeys having the uniting propolis cracked by a chisel, are lifted apart at one edge, and the paper is worked in, covering the space between the two. In a few seconds, all the bees above and below have rushed from the junction of the storeys, when the upper part is boldly lifted and stood upon the edges of a box. The paper is withdrawn, the new storey adjusted, and the upper one added without molestation to the operator, and perhaps no death by crushing even to a solitary bee. The use of carbolic acid will not injure the honey, as the whole of it quickly evaporates, while smoke, in excess, does impart a lasting bad odour to the comb.

In removing top combs for extraction, carbolised paper is put on under the quilt for a minute or two, when the bees hastily descend. The frames are lifted one by one, to have the few stragglers whisked off, and then are placed in a tin comb-box or a spare storey, over which a cloth is thrown. New combs are given, and all covered down; or the storey is exchanged bodily for that carrying the empty combs. The danger from robbers is at such times small, as no new combs would be added unless nectar was still abundant.

Harvesting from many hives, some of which will lose two or three tiers, necessitates more preparation, and considerable care if gathering is drawing to a

close, as bad temper and robbing are then easily induced. The rough plan of brushing bees back on to the top of the open hive is fraught with danger, for the odour rising attracts the thieves, while the stock, bewildered by the light, and kept in check by smoke or carbolic, is heavily handicapped in defending itself, Fix, therefore, a platform about 2ft. square (page 258) in front of the hive, resting one edge on the alighting-board, so that the bees, in running in, ascend a gentle incline. Driving the bees down as before, by carbolised paper is of great assistance; but whether we adopt this plan or no, a chisel is inserted, and the top box raised on wedges too small to permit a bee to escape; and now smoke is puffed through the opening, or the carbolic spray, or carbolised feather, is used (page 20), when the box is lifted on to a bottom board put to receive it. The paper is in turn transferred to the second box, while a cloth covers the first. The second box is now similarly removed, and placed over its companion, when the hive is covered down snugly, and its roof replaced. The frames are next lifted out one by one, each held by the ear, while the bees are jerked and brushed on to the platform, and the comb placed in a vacant storey provided for the purpose. When filled, this passes to a place of safety, and the second box is cleared as the first, its combs going into Box No. 1, which is immediately housed. Start now on another hive, preferably situated at some distance from the first, and fix in position the liberated platform. In this way but little excitement is caused, but should a mishap occur, it is better to discontinue for the day, if possible.

Keep no hive open a moment longer than necessary, and be particularly watchful that no bees get access to the removed honey.

Extracting should be done under cover—it *must* be, unless forage be quite abundant. The sticky, messy frames, as emptied, should be returned to the storeys whence they were taken, and then these, piled according to convenience, may be given again at *dusk* (not earlier) to the bees, to be cleaned out and put into condition for keeping for the work of another season. The quality of the honey gathered at different periods by the same stock, and even at the same period by different stocks, will often vary widely; and, in extracting a quantity, an effort should be made to secure that of highest type by itself, as superior quality, mingled with second-grade stuff, will but little raise the market value of the latter. Holding up the combs to the light (even if they have been bred in, the upper corners remain uncoloured) will assist in forming a judgment of the contents.

Comb honey, to which much that has been said in reference to extracted applies, if raised as a main or exclusive crop, presents, in some respects, an essentially different problem. The difficulties are greater, and the results less certain, and are only undertaken because of the relatively high price comb honey commands. For extracted honey, finished combs are given : the visits of the queen, should such occur, occasion nothing more serious than delay, however large the brood-patch : complete sealing is by no means necessary, while threatened swarming may without loss be commonly averted by emptying a few

frames. For comb honey, on the contrary, all ordinary systems require the bees to *build* their combs, either with or without the assistance of foundation: the presence of a single egg is fatal: every cell must be fully capped, while the giving of empty comb outside the sections will hinder or stop storing in them.

The difference involved in supplying foundation instead of complete comb is immense, for it must never be forgotten that bees are social in their instincts, their individuality is merged in that of the colony, they follow precedent, and they act in concert because they will to do as others have done. If these have crowded their brood-nest with honey, they will crowd it still; if drone-comb has been started, they will follow the pattern; if others have stored honey in their supers, they without question accept their lead, and there place their load. If, therefore, *we* can manage to give the cue, we may settle the plans they will follow; but when once the wrong path has been entered trouble awaits us. From this it follows that, in giving comb, its acceptance for honey-storing is certain; for the bee's instinct is unable to get behind the fact of our interference. The comb is to her part of her nest, because it is comb, and it is there above that it may hold the in-gathering, and our will is done as a natural sequence. Mr. Hutchinson truly says:* "Let the bees once get the start of the queen by clogging the brood-nest with honey, and that colony becomes practically worthless for the production of comb honey; and the oft-repeated advice to make

* "The Production of Comb Honey," W. L. Hutchinson, page 24.

room for the queen by extracting the honey, is equally valueless, as the bees will refill the combs the first thing they do." Be it noted it is worthless for the production of *comb* honey. All this points to the extreme importance of having, as far as possible, the brood-nest—*i.e.*, all the brood-nest combs—a block of brood before the sections are put on, and, in addition, the giving to our section crate, as far as practicable, an appearance of one that has already been adopted, when its adoption is all but a certainty. The most trivial matters will sometimes determine its acceptance, and in my early days of bee-keeping I made it a practice to pour and splash syrup about within every super, the moment before putting it over the hive: a few, rushing aloft to clear up sweets, joined by a larger contingent, just playing at follow-my-leader, frequently started operations which continued to a successful issue.

At the close of the honey harvest, unfinished, and in consequence, unmarketable, sections remain on hand. These, when extracted (page 480), become most valuable stock, and, placed in the first given section crate, either alone or in combination with those carrying foundation, will put us almost on a par with those working for extracted honey. The advantage, however, brings a difficulty. The combs will preserve the start they have over the foundation, and serious bulging will follow unless the now necessary separators are used in the crate. No cause for great regret this, as they are desirable under almost all conditions, although perfectly straight combs are obtainable without them (see pages 184 and 461). The Canadian narrow sec-

tions, exhibited in 1886, and raised without separators, of which so much was said, were only approximately regular, and, indeed, not nearly so regular as great slabs of comb raised by myself, and some others, many years before separators were thought of. The Canadian honey required to be cased in the order in which it was built, and then it was generally impossible to lift out a box without damaging its face, or the face of its neighbour.

Mr. Simmins' system depends largely upon the bee's preference for comb over foundation. Fig. 76, intended to explain the principle, but not the details, shows a space which would, in practice, accommodate not less than five or six frames for a hive of one storey,* and the combs built here may be utilised by being put into sections. If eggs have been laid in them, the eggs lose their vitality by the comb being kept a few days before it is given to the bees. The inventor depends more, however, upon combs built earlier in the year in an upper storey, under the stimulation of dry sugar feeding. These, cut into six, just fit $4\frac{1}{4}$in. square section boxes; and since all the boxes are supplied with combs simultaneously, separators are not essential, and Mr. Simmins does not generally use them.

The significant fact, however, is that bees so prefer to work in sections supplied with comb to *building* below, that the former will be readily stored and

* One-storey hives are not best suited to the Simmins' system. With those in tiers, starters only are given in the bottom storey, while comb is crowded into the sections. A loose comb is a bee's abomination. Fixing is followed by filling, so that the nadir unheeded is found to have made little progress even at the end of the season.

finished, while starters in the latter position make but slow progress, and the safety-valve against swarming is thus kept open in the form of a vacancy near the entrance.

The section crate must be so placed over the hive that no leak of air is permitted. Crevices should be carefully closed, and for this purpose old quilts, torn into strips, will be useful. When the sections have been started, the main difficulty is passed, and another box should be added below the first, when it is, perhaps, half completed; the second, by creating a gap between the progressing combs and the brood-nest, strongly stimulates the bees to fill it. Henceforth foundation is nearly equal to comb, as the situation is already an accepted one, and bees got thus far will generally, if properly handled, go through the season without swarming. Previous explanations apply—new crates, as needed, being added beneath, while filled ones are removed from above.

The danger of the queen entering has convinced most producers of comb honey that an excluder (pages 74, 98, and 114) of some kind, is, at the worst, the less of two evils. Opinions respecting the effect of an excluder are diverse, some stating that it considerably decreases the amount of honey, others that it makes no difference. It is impossible, of course, to dogmatise here, and comparison is impracticable; but I can conceive of no reason why the amount of honey should be lessened, except that it is likely by its presence to somewhat disincline the bees to adopt the sections, since it tends to isolate them from the main body. The excluder, however, is

of practical value, in that it prevents any disturbance of the frames in tiering up, and also gives most helpful control over the size of the brood-nest, the matter next to be considered.

It would be easy to give a long catalogue of distinguished honey-producers, who all declare in favour of small brood-chambers when comb honey is the object. In the early part of the season the queen should receive every encouragement to deposit eggs, for the great spring laying is the foundation of all surplus; but, as the summer advances, and the duration of the yield is measured by five or even six weeks (the date depending upon the flora and latitude), the production of large breadths of brood is fatal to high results. Let us imagine that the brooding, feeding, and sealing of a single bee, from the egg upwards, costs as much to the colony as storing four cells with honey—an estimate which careful attention to this problem has shown me to be moderate, even for ordinary yields. Then the production of 1lb. of bees, *i.e.*, 2lb. nearly of larvæ (see page 20, Vol. I.), will reduce the honey stored by 16lb.; if the comb has to be built, by probably 8lb. It is because a bee in a fair yield is able to requite the colony with many times its cost that a large population means surplus, but if the 1lb. aforesaid is produced at the *end* of the honey yield, the expenditure has been made without a possibility of return. The supposition that tremendous laying on the part of the queen is requisite right down to grey autumn, is most shallow—late breeding, where heather is in prospect, is feasible enough; but the queen may, and should, by a limi-

tation of the brood-chamber, be brought to reduced activity long before the period just now indicated. Mr. Simmins says, in speaking of swarms made for the raising of queens: "If the swarm happen to be taken before June, the number of stock frames may be made up to eight, after a week or so. If later than June 1st, six only may be used, or too much brood will be produced later than is beneficial to the production of a surplus;" and years earlier, while writing the first edition of "Modern Bee-keeping," I thus expressed myself: "Even in the best-managed apiaries it is often found, at the time the honey harvest opens, that some hives, though rapidly increasing, are not sufficiently crowded to take advantage of super space, while the honey yield is so short in duration, that to wait while the bees are multiplying is to lose it altogether. If comb honey be our object, wise management would now either unite, as we have suggested, or contract the hive, removing every frame, filled or unfilled, that does not contain brood, leaving only that which is *necessary* for the egg-laying of the queen, and using a division-board, as explained under 'Wintering.' The bees, though not particularly strong, are crowded aloft, and super boxes become ours where, but for this plan, we could have had no hope. But it must not be overlooked that, as the bees have no room for store in the hive body, they will be left so poor at the removal of the sections that sugar must be fed to them; but our profits, as well as our experience, if we have it, will cause us to do this with a cheerful heart and a generous hand."

The practical question—what should be the size of the brood-nest of stocks—admits only of an empirical answer, as the strength of the colony, the character of the district, the season, and the part of it to which the question refers, are all concerned in its determination.

The ground is covered by the double statement that the brood-chamber should be as large as the queen can be got to fill in anticipation of the great ingathering, and as small as it can be made (so that swarming is not induced) when the bees raised in it will no longer pay for their upbringing. No nectar flow from any single source is long enough continued to forbid a contraction of the brood-chamber at the time the surplus receptacles into which it is to be stored are put on the hive. If, however, a second source, such as heather after clover, is in anticipation, the reduction of the brood-chamber would then be premature. This reduction is a perfectly normal process, and is brought about in the home of the wild bee by incoming honey, at the very time we are recommending its adoption; but by adding crates or extracting we prevent the honey from extending downwards, so as to greatly limit the queen; other means are therefore necessary.

Large hives with deep frames can have the brood-chamber reduced by dummies, but the top area is lessened, and supers are not worked so freely where brood is not beneath. Making the frames shallower increases the supering surface; and if the queen be confined by excluder to the bottom box, this will be packed with brood while *all* the honey is placed

above at the disposal of the bee-keeper. A contracted chamber, thus filled, gives as much room for the exercise of the queen's energies as a large one partly filled with honey, and overloaded with pollen.

The question of the brood-chamber of the stock has some relation to that of swarms, which, however discouraged, cannot be ignored and overlooked; and here, as in so many other cases, it is impossible to draw a hard-and-fast line to be ever followed. If the swarm be early, and the harvest lengthened, then it may be converted into a honey stock by the power of the bees it is able to raise, and a very restricted brood-chamber would be unwise, while every encouragement to egg-laying should be given; but if it do not issue until the flow has already commenced, the swarm must be made a gatherer of surplus at once, or it will yield no profit during the current year beyond its own establishment. Suppose the swarm to issue from a stock working sections, then, without returning it, we may treat it as described (page 165), and, by giving it a very small brood-chamber, force it at once to continue the sections moved from the parent and placed over it, for the hive proper would not really hold all the bees. If we fill the hive with combs and cover down by excluder zinc, the queen, surrounded by a dense population, would lay rapidly, and soon a large part of the power of the swarm would be taken from super work, while others would store in the unoccupied cells. If, however, foundation were given, the conversion of this into comb would occupy some time, and so delay egg-laying and honey-storing below to the present advantage of the sections.

Mr. Heddon has advocated giving foundation, and not comb, for a reason now apparent; but Mr. Doolittle, Dr. G. L. Tinker, and others, assert that the bees should build their own combs, and not have even the aid of foundation; while Mr. W. L. Hutchinson,* a leader in the same school, has given us the results of his experiments in hiving swarms in alternation as they issued, on full foundation, or with starters only, and has declared in favour of the latter. He thus expresses himself: "I have many times hived a swarm upon eleven frames of empty comb, each a foot square, and in three days found every comb full of honey, with the exception of a space, perhaps, as large as my hand, in the centre of one of the middle combs, which was occupied with eggs; and, were I raising extracted honey, I should most certainly give a swarm all the empty combs it could fill, *but not in the brood-nest.* The advantages to be gained by allowing a newly-hived swarm to build its own combs in the brood-nest are fully as great in raising extracted honey as in raising comb honey; but, in either case, the queen must be kept in the brood-nest by means of a queen-excluding honey board.

"If a swarm is hived upon frames with starters only, the first step is necessarily the building of comb. Now if a super filled with drawn or partly drawn combs (not foundation) is placed over the hive, the bees will begin storing honey in the combs at the same time that comb-building is begun below. If a queen-excluder keeps the queen out of the supers, she

* "The Production of Comb Honey."

will be ready with her eggs the moment a few cells are partly finished in the brood-nest; and if the latter has been properly contracted, she will easily keep pace with the comb-building. The result is that nearly all the honey goes into the supers, where it is stored in the most marketable shape, and the combs in the brood-nest are filled almost entirely with brood."

It has been objected to this system that the brood-nest would thus get in large part filled with drone-comb. To this I can reply, from direct experiment, that the stricture is unfounded unless there be mismanagement. The bees perfectly well recognise that breeding can only be carried on beneath the excluder, and they follow their usual course, viz., they build worker-comb to accommodate the brood, and occupy outlying parts, if such be given, with store, for which drone-comb is constructed.

In hiving this summer (July 8th), upon six standard frames with starters only, 5lb. of Cyprians, headed by Madame la Voyageuse (page 350), I placed, at the same time, a 24lb. section crate above, containing about ten boxes of extracted comb, and the remainder foundation. Every part of the crate was filled with bees the same afternoon. The sections were completed perfectly to the bottom rail, their caps, of course, being thin, and too transparent, as is the practice with Cyprians; but no speck of pollen was added. The brood-nest was filled with unmixed worker, except about a quarter of an outside comb, which was drone. At the removal of the super, the brood extended, in all but the side combs, absolutely to the top bar, the attachment cells being rounded

above in order to fit the larvæ. The statement that on this plan the pollen is carried into the sections, as Mr. Corneil complains, does not agree with my restricted experience of it. Some, however, corroborate Mr. Corneil, and the difficulty would occur if the brood-nest were restricted excessively. From eight to six standards, according to season, would appear to be correct. Swarms do not ordinarily carry pollen for three or four days; but if no cells then be found to receive it, undoubtedly it would be carried aloft, and more probably if narrow sections without separators were used. Mine were $4\frac{1}{4}$in. by $4\frac{1}{4}$in. by $1\frac{7}{8}$in. The whole plan is on its trial, but experiments on a small scale may soon decide its true value.

What has been said of harvesting extracted honey applies largely to that in the comb, especially if the crates are removed *en bloc*. The bees remaining after driving by carbolic may be got rid of by lifting out the boxes, and giving each a rocking shake and a whisk with a brush. In inserting a new crate beneath one in progress, in the absence of an excluder, the half bee-space tray (*tr*, Fig. 113) is of great service, as it saves the frames of the hive from any displacement. In order to facilitate simultaneous finishing of the boxes, put those containing comb on the outside, those having foundation only, in the centre. Towards the end of the honey harvest, should the boxes be removed as finished, it is well to contract the crate by adding my dummy boxes in the vacancies. These are simply blocks the size of sections, or sections themselves, with thin wood on the otherwise open faces. Now, tiering down and group-

ing the sections wisely will save us from having any large number unfinished, but it must not be expected that those slowly worked will equal in appearance those obtained earlier. Sections must not be left on after the income has fallen as low as expenditure, fully finished or not, or the bees will spoil all by beginning to break the cappings and carry down the honey.

The sections housed must be carefully kept secure from bees, and in a warm, dry room. Cases to hold one or two dozen, with glass sides, are a great convenience, and permit of an assortment of the stock. Those poorly finished should be extracted. Those containing dark-coloured, inferior honey, may be fed back to the bees behind a division-board, or in an upper storey. The comb will be of great service the succeeding season, as we have seen. Tempting packages for sections, now so common, have their value as increasing sales, but any description of them lies outside our present purpose.

Sections do not keep so well as extracted honey. They are unsaleable if candied, and must be melted down. In a damp air they weep, and rapid changes of temperature damage them, many cells showing that they are defective (page 175, Vol. I.), so that evenness of colour is lost. They are difficult to pack, and fragile at best. Extracted honey, liable also to candying, brought about mainly by the action of light, should, if in bottle, be kept in store in the dark; but, unlike comb honey, when candied its transparency can be easily regained, without the least detriment to quality, as explained at page 487.

Extracted honey from virgin combs is altogether

the equal of that in sections, and, ultimately, such must it be. Formerly, muddy specimens, more the product of the aphis than flowers, could even squeeze their way into the prize list; at that time the whole nursery went whirling round to get a few pounds of pollen-stained stuff; soon the mistake was seen, and, barring brood, we yet held to old brood-combs, as being tough enough to bear extraction. Now the extractor is so improved that virgin combs can brave the ordeal; and since those built on thick and wired foundation may be used, there is no fear at all that they will unduly suffer.

The truth is better faced; the specks, tiny though they be, found in that from combs in which breeding has taken place, consist, mainly, of larval excrement (see Fig. 4, Vol. I.), a fact which will convince the far-seeing that I am urging no fancy, but that which has much to do with the development of the popularity of honey itself—a popularity which will continue to grow, unless blind folly prevent. If prizes were given for honey extracted from combs which had never been contaminated, and the capable judge, with a good hand magnifier, could determine the point instantly, an improvement in the quality of the article would soon be produced, far transcending, in effect, any of the tasty labels now so common. A name should be given to it, and although the word virgin, as applied to comb, covers an old blunder, it is unremovably crystallised into the language; and so "extracted virgin honey" might not be inappropriate, especially as it would appeal correctly to a vague idea in the public mind.

CHAPTER X.

WINTERING.

Causes of Winter Mortality—Reducing Combs—Winter Passages—Candy Cake—Hill's Device—Hybernation Theory—Age of Bees—Most Favourable Temperature—Action of the Stomach Mouth—Honey as a Heat-forming Food—Necessary Renewal of Air in Hive—Daily Loss in Weight—Bowel Distension—The Pollen Theory—Hive Walls—Wintering Weak Stocks—Experiments on Non-conductors of Heat—Cork-dust—Ventilation—Dampness: Causes of—Clearing Floor-boards—Snow-glare—Starved Bees.

NO care during the season of activity can compensate for neglect of the bees' comfort and necessities during the period of repose. A winter well passed has more to do with rapid building up in the spring, and so with all subsequent success, than the inexperienced can imagine. Setting on one side the misfortune of disease, or the accident of queenlessness, the fatalities which occur during winter may be put down, in nearly every instance, to one of four causes: paucity of bees, insufficiency of food, want of proper protection, and errors in ventilation. The first two difficulties will not meet those

who have acted in accordance with the recommendations given under "Uniting," pages 432 *et seq.*, and "Food and Feeding," pages 379, 409, 416, *et seq.*

With very strong stocks, the bees will not condense sufficiently to make the desirable contraction in the space they occupy, until the nights have become actually cold, and I have found it often impossible to get all packed up in wintering condition until November. Feeding should, however, be all completed by the end of September (page 417), but failure in this may be counterbalanced by abundance of candy (page 396). In finally arranging, remove all needless combs, reducing the strongest to eight standards, and making six the rule for good stocks. At the sides place thick, tight-fitting dummies, or pour in chaff behind thin ones. Take from those having an *embarras de richesse* and give to poverty-stricken neighbours, so that all may have abundance, and yet a sufficiency of empty cells to accommodate the bees, some of which, as the external air falls to 45°, begin to crawl in head first, exposing the breathing apertures ("spiracles," page 33, Vol. I.) to the slowly passing air-current, while others occupy the interstices between the combs. They thus condense their cluster, reducing its external surface; and as each bee, so to speak, is a tiny furnace, carrying on a process in its tissues and fluids which is the exact chemical equivalent of oxidising honey, temperature is the more easily sustained. In this the bees are assisted if the combs are set rather wider apart than the normal distance—$1\frac{5}{8}$in. from centre to centre being usually accepted as most fitting.

Winter passages are recommended by many; these consist of a small hole, $\frac{1}{2}$in. or more in diameter, cut through each comb, about the middle of its length, and one-third of its depth from the top bar, and having a curled, stout shaving or wooden pill-box, without top or bottom, placed within, so as to prevent the bees filling the opening. Commonly, the bees of the several seams are literal detachments, and when condensation takes place during cold spells, many in the outside seams, unable to pass round the edges of the icy frame, get isolated from the main body, and freeze to death. With winter passages they pass *through* the comb; but these disfigurements are not at all necessary with the plans hereinafter described. A cake of candy (*o*, Fig. 19), as suggested on page 397, gives passage-way above the frames, but the paper is liable to collapse; and last winter I cast the candy in section boxes, one side of which had been made level by cutting, and the result was excellent. One of these, placed on its side, and covered down snugly under the chaff-tray, keeps the bees above, feeding, and, as the candy disappears, they cluster in the space it occupied, holding almost all their honey under immediate command, and maintaining heat with great facility; while there are no bees that are in any way separated from the whole cluster. With this arrangement, and the wide setting of the combs, the empty cells before referred to are hardly required.

In the States and Canada, whose winter climate is for the most part much more rigorous than our own, a plan having much in common with that now given

is adopted by some of the most successful bee-keepers. It is known as Hill's device, and consists in placing over the frames several curved laths so nailed together, concave side downwards, that they, forming a shallow dome of lattice work, hold up the top covering, and give opportunity to the bees to cluster above the top bars. I prefer starting with a cake of candy, as it makes the clustering of the bees *above* absolutely certain.

As we proceed, the necessity for husbanding the heat of the cluster, as far as practicable, will become apparent. In order to grasp the position, we must trace the manner in which bees maintain their temperature, and the fluctuations to which it is liable—a matter bound up with the management of the mouth and top of the hive. All advanced apiarians are agreed that bees do require considerable ventilation, notwithstanding the extraordinary whim, much discussed a year or two since, that all the air needed in winter may pass through the hive side; but they are not agreed as to the manner in which this ventilation is best given. Bees hybernate, as the Rev. W. F. Clarke has recently taught, and respecting which he is undoubtedly original, although he will find I gave the outlines of hybernation* in bees six years earlier. Yet they are, strictly speaking, warm-blooded, maintaining a temperature which, though not constant, is not suffered in the centre of their cluster to sink to less than 65°, even in the most severe weather. This temperature is kept up with the least effort

* "The Causes of Abdominal Distension of the Hive Bee during Winter," Frank R. Cheshire, May, 1879.

when the surrounding air stands at about 40°, or a little more, which is, consequently, the most favourable for wintering; and could it be preserved without variation, as it practically may be by the plan of "cellaring" (adopted largely in America, but here little used, because our climate is relatively so mild that bees may be quite successfully wintered on their summer stands), the bees would come through to the spring, not only in good order, but, for the purposes of the colony, young, with life before them.

The lives of bees vary much in duration according to the season of the year, for their age is not to be reckoned by number of days so much as amount of service and the sum of the energy they have been called upon to exert. In summer, when everything prompts to the highest activity, the store of vitality—the birth heritage of every bee, and apparently a uniform and constant quantity—is quickly worn out, and at six weeks, or at most two months, decrepitude or death supervenes. But during the winter, if conditions are favourable, the busy throng gives place to the quiescent cluster, yielding usually but the slightest evidence of movement. In this restful state bee life is paid out slowly, and, at five or six months, those inhabitants of the hive that were hatched so late as to have no demand for honey-gathering made upon them, are still possessed of so much of their initial vigour that they can labour for the colony yet a month or two when spring returns. Such bees, and such only, can be said to have been successfully wintered.

The conditions regulating the amount of activity of

the cluster during winter, to which I drew attention in 1879, have been remarkably corroborated by Professor N. McLain, who has detailed some experiments on this matter worthy of careful attention. His experiments were conducted in a cellar over the temperature of which he had full command. The bees entered the hybernating state when the external temperature was between 48° and 52°, the variation depending upon the amount of humidity present. At 41° Fahr. he found the shape of the cluster most permanent; while that temperature was maintained, little change in the shape or location of the cluster could be seen, and functional activity seemed to have reached the minimum; even respiration appeared to be suspended,* and the outlines of the clusters remained unchanged for days together. Unrest and activity increased as the temperature neared the zero point. The degree of activity at 44° was not much greater than that at 41°. At intervals of about one week the bees roused themselves to activity, the form of the cluster changed, and, after three or four hours of cheerful and contented humming, having in the meantime appeased their hunger, the cluster reformed into a compact body, humming ceased, respiration became slow, and profound silence reigned in the hive. The more perfect the conditions, the longer the periods of inactivity.

The reason of this fact, observed by Mr. McLain, is as follows: During the periods between *visible* feed-

* Gaseous diffusion and oxidation are, of course, not really suspended, but only greatly reduced, enough remaining to keep up the cluster temperature given on page 518.

ing, the bees are actually feeding upon the store of honey taken into the honey-sac (page 60, Vol. I.), where it is held until appetite requires appeasing. Then the stomach mouth—a marvellous structure, lying behind the honey-sac—passes a ration backwards to the true stomach, whence it enters the fluids of the bee, to undergo oxidation, for we have already seen that honey, and saccharine substances generally, are the materials from which heat is produced (see page 376). These consist of two gases, oxygen and hydrogen, in the proportions in which they exist in water, in combination with carbon; and although it would be scientifically inexact to say that honey consists of carbon and water, for our present purpose it is convenient so to regard it. The bees clustering together, if surrounded by the most favourable conditions, are able to maintain, in their centre, the 65° previously referred to, by the slowest imperceptible breathing; but if external temperature sinks, the bees, without some counteracting action, would be prejudicially chilled. This they prevent by elongating and contracting their abdomens (a movement which may be seen in any bees recently settled), thus rapidly drawing in and expelling air by the before-mentioned spiracles, fourteen in number. The cold, intensifying, needs further efforts, and now the wings, gently flapping, producing a buzzing murmur audible outside, pump the air in and out with vigour, and fill up the tracheæ (page 147, Vol. I.), and hold off the grip of the enemy; for, the more rapidly this breathing is carried on, the more oxygen is brought into contact with the honey, and the more of it is consumed, and the greater the

heat evolved. The honey-sacs now inevitably are emptied more rapidly, necessitating their refilling at the cells at reduced intervals.

A supply of fresh air to the cluster is, from all this, clearly essential, for as the heat is in proportion to the honey consumed, so it is in proportion to the products of oxidation—the noxious gas (carbonic acid) and the water—as a reference to the following Table will show, in which all but the main constituents of the honey have been disregarded for simplicity's sake.

24oz. honey	9oz. water	=	9oz. water.
	6oz. carbon	=	6oz. carbon.
	8oz. oxygen, 1oz. hydrogen	=	9oz. water.

The 6oz. of carbon being united with 16oz. of oxygen from the air, we obtain 22oz. of carbonic acid gas, which, with the 18oz. of water, are thrown into the air of the hive by the consumption of 24oz. of honey.

Let us first trace the 22oz. of carbonic acid gas, occupying about twelve cubic feet at ordinary temperature. Dealing with a stock wintered on seven standard frames, set at 1⅝in. from centre to centre, we find:—

Seven frames, each 8½ cubic inches, wood	=	59½	cubic inches.
20lb. honey, specific gravity 1·386	=	400	,,
1½lb. wax, specific gravity ·965	=	43	,,
Pollen estimated	=	20	,,
Bees*	=	100	,,
		622½	,,

* The bees would fill more than 100 cubic inches in a measure, but the large amount of air lying between and amongst them must, for our illustration, be subtracted.

Disregarding fractions, this, subtracted from 1500 inches, the solid content of the hive, gives 878 inches —*i.e.*, an air-space which we may, for simplicity's sake, regard as half a cubic foot, or 864 cubic inches. Therefore, the twelve cubic feet of carbonic acid, produced from the consumption of 1½lb. of honey, would fill the air-space in the hive twenty-four times. Nor is this all. Air is only one-fifth—by measure—oxygen, the other four-fifths being nitrogen; and carbonic acid occupies precisely the same space as the oxygen which unites with the carbon to produce it. Therefore, if the whole of the oxygen introduced had been converted into carbonic acid, the air in the hive must have been entirely renewed $24 \times 5 = 120$ times; and, further, the presence of carbonic acid is so deleterious that 5 per cent.* only of the oxygen could be utilised; the proportion being also limited by the laws of gaseous diffusion (interchange) in the breathing-tubes of the insect. Thus it is impossible to resist the conclusion that 1½lb. of honey cannot be oxidised for heat-production without the air of the hive being changed 2400 times.

Authorities, with unusual agreement, state that the loss in weight of a wintering colony in which breeding is suspended is less than 2lb. per month. With ordinary protection this is about accurate, but it may be reduced to rather less than 1lb. per month, or about ½oz. daily (see page 417). The 1½lb. would,

* In a similar illustration, given ten years since, in my "Practical Bee-keeping," I stated 10 per cent. as probably the very largest amount that could be utilised. Subsequent experiments have shown 5 per cent. to be very near the truth.

therefore, represent forty-eight days' rations, and make the daily essential number of renewals of the air volume of the hive to equal $2400 \div 48 = 50$; *i.e.*, the air of the hive, even during this very restricted food-consumption, would need to be changed completely during every thirty minutes—a fact with which we shall have to deal presently, in considering the question of ventilation.

The escaping vitiated and damp air from the hive carries away, in its altered form, nearly the whole of the consumed honey, so we see why, during continued cold weather, stores are reduced, it may be many pounds, while the bees have had no opportunity of discharging themselves. Excrementitious matter is scarcely produced at all by consumed honey, its saccharine constituents, as we have already seen, yielding nothing that does not pass off by the breathing apertures; but every activity is associated with wear and tear of the tissues, and this provides, although in restricted quantity, residua, which collect in the bowel, as do the non-digestible substances contained in large amount in the pollen which the bees consume to make good the wear and tear aforesaid. A condition of most complete rest—the hybernating condition—is accompanied by so little wear and tear, and, consequently, so small a consumption of pollen, that the bowel does not become unduly distended, even after months of confinement by stress of weather; but with inadequate protection, accompanied by continued very low temperature, the bees being forced to the before-mentioned vigorous agitation of the abdomen and a gentle flapping of the wings, the bowel becomes loaded beyond endurance, and the bees, too heavy or too chilled to fly,

discharge themselves upon their combs, producing a condition which has been incorrectly described as "dysenteric," dysentery being a well-defined disease, producing the symptoms described, but from a different cause (see next chapter).

"The pollen theory," so called, now much advocated in America, as usually expressed at least, wrongly lays all the evil at the door of the pollen and asserts that bees need nothing but honey or sugar during the winter, and that, in consequence, no pollen should be allowed them, when the disagreeable results mentioned could not follow. It is true that without pollen the bowels will not become distended, but it must not be forgotten that the bees will suffer emaciation from semi-starvation (page 402). All creatures consume instinctively fitting food. Dogs long deprived of nitrogenous aliment will die of starvation with butter, which they commonly so much love, untouched before them. Honey the bees consume to enable them to produce heat and give forth energy, and pollen to renew their nerve and muscle waste, selecting the one or the other, as Nature needs. The right remedy for bowel distension appears to me to lie in carefully securing good wintering conditions, and so saving that waste which makes nitrogenous food necessary. In America, this possibly means cellar wintering with a fairly dry air at a sustained temperature of 43° or a damp air 2° or 3° higher. Healthy bees, properly wintered in this country on their summer stands, would rarely, if ever, consume so much pollen as to occasion the difficulty under consideration The removal of the pollen has been found by many

to occasion a loss of condition, which tells much against the rapid building up of the stock in the spring.

Honey as a food enters into the living fabric before it furnishes material for oxidation, yet it remains true that loss of heat is exactly equivalent to loss of honey. This points to making the surrounding of the cluster as non-conductive as possible, not only thus saving stores, but the vital energies of the workers, which must otherwise also be consumed in keeping up temperature. The hive walls first require attention. The volume of opinion in favour of highly non-conductive hive sides would put the question beyond the necessity of discussion, were there not some who constantly seem to imply that bees need little protection, and that probably thin hives are the best. It should be instantly conceded that thin sides are practically as good as the most non-conductive if too much space is given, or if the top covering is deficient. It is useless to fasten the window if the door is off its hinges. Mr. Raitt's pithy saying, "The best protection for bees is bees," is perhaps the most incisively expressed argument we have in favour of abundant protection. Little lots winter badly, but cover them by bees that will absolutely prevent their heat escaping, and you give them the best possible protection. But do not the protectors need help? Yes; by more bees if we can provide them, by the best non-conductors available if we cannot.

The evidence that strong stocks come through all right in thin hives proves little, and is no test. The plan that will enable the very weak to winter well on small stores must be the most helpful to

those that are strong; and experience shows me that there is no risk with a pint of bees on two frames, properly handled, in the South of England, and I have wintered a teacupful, which subsequently built itself into a stock, with no help beyond food. We have no need to see how much our bees can sustain, but should rather desire to bring them through till April, little tried, and ready for the severe labour of giving us the nurses for the heavy population which is to do the work of honey-gathering, and so prevent spring dwindling, which I venture to believe, in common with some of the best observers, is almost always the result of excessive effort, rendered necessary by poor protection.

Some years since, I made experiments on hive walls, which have led many makers to modify their patterns. I took a number of tin chambers, each holding 12oz. of water. After filling with water at 200°, they were placed in boxes, representing different descriptions of hive sides, all of which had been before carefully brought to a uniform temperature, and then the time occupied by each in falling through a certain number of degrees was noted. For this very delicate thermometers were used, and the calculations based on Newton's Law of Cooling. The following results were made clear: If a hive side of $\frac{5}{8}$in. pine have its protective power represented by 1, that of a double side with 1in. dead (?) air space would equal 4, while the same wooden sides packed tightly with chaff would equal 10. It has been argued that air is a better non-conductor than any solid substance, and, therefore, is better than any form of packing; but the fallacy

lies in this, that the so-called dead air is not dead but circulating. It rises against the inner skin of the hive, and falls where it touches the outer, and so is eyer acting as a distributor of heat. In the same way, a man in bed might argue that the air is a better non-conductor than the bed-clothes, in which he would be perfectly correct; but if he were to add, "I shall, therefore, be warmer without them," universal experience would contradict his conclusion. The bed-clothes are useful because they prevent the circulation of air, and that next the body, being warmed, is imprisoned instead of passing away for cold to take its place. Further experiments proved that cork-dust (a waste product used for packing Spanish grapes, as sent to this country), in lieu of the chaff packing, gave a non-conductivity to be represented by 14. The cork has many advantages; it is perfectly effective even with poor carpentry; it is not liable to mildew, and if it becomes damp, it does not droop down between the wooden skins, as chaff would do.

In thin hives, in hard weather, the inner face of the wood is too cold to permit the bees to touch it, so that they are driven to remaining in the middle of their frames, exposed on all sides. In those packed as described they winter, by preference, against the hive wall, and are thus only exposed on one side, while they close the frame ends for themselves, and can always pass freely from comb to comb without a possibility of getting lost in detachments; in addition, by having the entrance 5in. or 6in. long at the corner, the bees have always sufficient air, and work round the hive as the store is consumed.

The idea that thin walls are superior to thick because the sun's heat in spring passes through to warm the bees is certainly inaccurate. If the transitory advantage existed, it would be at the cost of constant loss, but it does not exist. Bees maintain 65°, and must uninterruptedly, though very slowly, lose heat through the hive walls until this becomes the temperature of the external air. Those, therefore, in the thicker hives will be warmer until this external temperature is reached, but before then the bees would be in full flight, and beyond the need of sun-warming.

The non-conductivity of hives is almost as needful for summer as winter, and does not a little in aiding in checking the swarming fever. Single-sided hives may be covered with an outer case, and chaff packed between. Treated in this manner, single Stewarton boxes (Fig. 15) winter admirably. Chaff is filled in around, while 2in. or 3in. of it is patted down above. Weak stocks which it is desired to keep separate, for preserving queens perhaps, may be most successfully managed in twin hives. Put them on such a small number of frames that they really help each other by clustering against opposite sides of the division-board. A sort of ante-chamber may be made by putting a division-board, with entrance-way beneath it, in front of one of the lots, so that the bees pass from under it into the ante-chamber, which has, on one side of it, the ordinary hive mouth, by which the open is reached.

Whilst the population is strong and the external temperature not too low, bees ventilate their hive (page 277) by a system of fanners in different parts,

and especially near the hive mouth. These keep up a constant current by uninterruptedly flapping their wings while they hold on with their feet, the air of the interior being scarcely less pure than that without. Very strong colonies, if visited at an early hour on chilly spring mornings, will be pouring out a stream of condensed vapour—popularly steam—while the water from it will continue to drip from the alighting-board, and if a lighted candle be placed in the outcast of air, it will be at once extinguished. But in biting weather the little labourers whose earnest efforts to secure an untainted atmosphere may often shame us, are driven from the door to the cluster, where, closely huddled together, they resist a temperature in which a single bee could no more continue its vitality than could a single coal continue to burn in the fire-grate. But air, although the fanners have ceased, is no less necessary than before, and our calculation shows the large amount actually consumed. If it is all to pass the hive mouth, this must not be greatly contracted, or the fallacious idea of "keeping the bees warm" will make them possibly the victims of cold. Bees stifled by contracted hive mouths, and the careful closing of all apertures above, are in the condition of coke in an Arnott stove with the draught-hole closed. The process of heat-production cannot go on, and the bees, stupefied by carbonic acid, possibly drop from their cluster to die, and, in dying, close more completely the narrow opening by their bodies.

I strongly advocated, in former years, that ventilation should be allowed through the top cover; further developments have made it doubtful whether this is

so necessary as was supposed. If a sufficient opening (of 5in. or 6in. at least) be allowed at the entrance (in addition, a ring of wood, 2in. deep, between the hive and its floor board lifting the frames, is a valuable assistance), top ventilation may be omitted, and American cloth be placed over the bees. It has, however, many disadvantages. I prefer *slow* upward ventilation, and earnestly advocate a chaff-tray, regarding the splendid covering it affords as far more important than the hive side itself (pages 61 and 409), especially if we give space above the frames, when notions of portability and cheapness may make us content with single sides, notwithstanding their inferiority to cork-packed ones. For wintering, the chaff-tray should hold 4in. or 5in. of chaff, well patted down. The sacking should be loose, so that it may fit the hive top accurately, for small crannies allow most damaging leaks of heat. A calico first goes over the candy or section-box, as previously explained, and then a thickness of flannel—but this may be omitted—and the chaff-box follows. Carpeting fits badly ; if creased at all, a direct through current, which punishes the bees severely, is permitted ; and on the usual thin hive side it is hardly possible to avoid those gaps which have made many denounce all top ventilation, quite overlooking how often this has been given in a manner all must condemn.

Dampness is a great enemy to wintering bees. Prof. McLain noted the critical temperature to be less in a damp than a dry air (page 520), the reason being that water has an enormous capacity for heat (specific heat) (page 68), whether in the liquid or vaporous form ; the

latter abstracts heat from the bees, and intensifies their struggle. The water produced by the honey is thrown off in vapour, because the cluster is warm. If the hive is thin, or the bees small in numbers, and, in consequence, distant from the sides, or if the top protection is scanty, the heated vapour is immediately deposited as dew, and the interior of the hive is wetted. When the sides are so non-conductive that the inner faces are not below the dew point of the interior air, the hive remains dry; and since wood conducts more freely than cork-dust, the inner lining should be as thin as notions of strength will allow. In *gentle* top ventilation, the heat of the cluster just beneath the roof keeps the part in contact with the bees both warm and free from damp, and the air passes off, carrying the moisture with it. The combs below are not mildewed, nor do they run with dew. If dampness appear at all, it is behind the runners, beneath the ears, where the temperature commonly falls to the lowest point; this, however, causes neither damage nor inconvenience.

During or after long spells of cold, some recommend a hooked wire to be passed into the mouth of each hive, in order to remove any dead bees likely to choke it, or stocks may be lost from stifling. I should regard any such necessity as a proof of an error in management. Yet the cautious bee-keeper will, when the weather is mild enough to permit of a winter's dance after a cold spell, walk through the apiary, and probe any stocks around whose doors bees are not flying, to ascertain whether the exit is free. The floor-board should gradually slope towards the mouth.

Snow should be removed from alighting-boards, for, although it is not to be feared while light and fleecy, it is likely to get partly thawed and re-frozen, when it would work mischief. If it cover the ground, and the sun commence to shine brightly, the glare upon it will frequently draw bees forth by the thousand, the majority of which will get too far chilled to regain home. Stop the glare, however, by placing a board in front of the door temporarily, or narrow the anti-robbing entrance (page 422) till no direct sunlight finds it way to the interior.

If by any mischance a stock should be found apparently starved, try at once a very warm room, and sprinkling with *thin* syrup, when often those supposed to be dead will recover. Feeding with candy or barley sugar must then be continued till spring.

Mr. McLain has recently reported very favourably of a special food he has prepared for building up stocks which have passed the winter and taken a good flight in the spring. It is fed in the same way as honey or syrup, and is intended to provide the elements essential in brood-rearing. His recommendation carries weight; but I have had no opportunity of trying it, and it appears to me to supply material in a form better suited to the assimilative powers of plants than of animals. The recipe is as follows: 10lb. of sugar, ½ pint of dairy salt, two tablespoonfuls each of bicarbonate soda, rye flour, and finely-powdered bone ash, one tablespoonful of cream of tartar. Mix thoroughly, add two quarts of hot water, stir till dissolved, and boil for two or three minutes only.

CHAPTER XI.

DISEASES AND ENEMIES.

Bees are subject to Diseases: Reason for—Foul Brood—Symptoms of Chilled Brood—Micro-organisms—Schonfeld's Experiments Disproved — Staining — Bacilli Discovered — Adult Bees Diseased — Eggs Infected—Bacilli Alvei—Chronic Attacks: Reason for—Processes of Cultivation—Sterilising—Colony Form of Bacillus Alvei—Spore Formation—Artificial Infection — Manner of Propagation of the Disease — Salicylic Acid Cure — Phenol Cure — McLain's Plan—Camphor, &c.—Bacillus Gaytoni —Diverse Organisms — Torula and Dysentery — Wax Moth — Preserving Combs — Death's-head Moth—Braula Cæca—Tits—Toads—Mice—Wasps —Earwigs—Ants—Snails, &c.

THE all but universal opinion, that bees have general immunity from diseases, except the much-dreaded foul brood, and, perhaps, dysentery, I have during the last three years shown to be extremely wide of the truth. Sickly bees have neither pale cheeks nor sunken eyes, and, therefore, all were accounted equally healthy; but the use of the dissecting-knife and microscope

reveals the presence of not only contagious or zymotic diseases, but occasionally curious organic disorders; *i.e.*, in the viscera of the large number of workers I have examined, one ailment of the latter kind—a form of liver trouble—has occurred a considerable number of times, and in bees coming from many different localities. The Malpighian vessels (page 61, Vol. I.) become loaded with, and surrounded by, a dark yellow-coloured oil, contained in cells, until the half, perhaps, of the abdominal cavity is filled. No practical purpose would be served in further describing the organic afflictions of the poor bee, or in detailing the physical deficiencies from which she occasionally suffers, such as defective eyes, imperfect sting, crumpled wings, or incomplete antennæ, since neither the physician nor the surgeon is likely to devote his attention to individual cases. It is here sufficient to remark that these flaws arise either from a defect in the mother, or unfavourable conditions in the colony—too low a temperature, or a dearth of water, being the usual cause—although they are sometimes due, as we shall presently see, to the existence of a disease which is wasting the vitality of the general community. Especially is this true in that most curious occurrence of hermaphroditism, of which, hereafter, I will endeavour to give the key.

The contagious diseases of bees, unlike those that are functional or organic, frequently attack the larger number of individuals composing the colony, while the malady may travel with devastating effect from stock to stock, until the whole apiary is ruined. They are caused by the growth and rapid multiplication

within the living frame of minute vegetable organisms, commonly spoken of as germs, or micro-organisms, which may be passed from individual to individual; and hence the possibility of infection.

When we remember that bees live in the closest contact in very numerous colonies; that their usual system of inter-communication is by actual touch; that they habitually pass food from one stomach to another, while all the food they have has been carried either within or upon the bodies of their fellows; that their very home is formed of one of their secretions, and that their beds, cradles, and larders are all interchangeable, we shall admit that the circumstances are such as would appear to favour the development of contagious diseases. That they have done so is fully proved by a careful examination of the case, for I find the bee suffering from several distinct kinds of organism, producing symptoms and results which I have to some extent formulated, but which yet require much patient devotion on the part of the investigator. Of these germ diseases, foul brood, as the most terrible and widespread, demands our first attention.

Some indistinct references, made by ancient writers as early as the Christian era, to a devastating disease existing then amongst domesticated bees, render it not unlikely that the malady until recently known as "foul brood" is far from a novelty; but be this as it may, it is certain that not until very recent times have its ravages become so frequent as to make it the terror of bee-keepers. Our modern methods and facilities of transit have been the

occasion of spreading far and wide that which formerly existed, though confined to narrow limits. In ancient days, bees did all their own travelling, and that at swarming time; then they rarely changed hands, except at the death of the owner, for the selling of a hive was discountenanced as unlucky even half a century back; but now bee-dealing is a well-established industry, both here and on the continents of Europe and America, so that bees are continually passing, not only from district to district, but, in the persons of queens and attendants, even from one country to another. Man, then, suffers not alone from diseases propagated by modern civilisation, but the animals which he has associated with himself necessarily suffer with him. Let us consider the matter under three heads: Firstly, the symptoms and nature of the disease; secondly, the means of its propagation; and thirdly, the methods of its cure.

First, The symptoms and nature of the disease. My readers are acquainted with the appearance of a comb removed from a healthy brood-nest during the breeding season. If the larvæ are all unsealed, those most advanced occupy the centre, presenting to view the sides of their well-fattened bodies, as they lie curled, in precisely similar positions, at the bottom of their cells, which they, in large part, fill; the younger and less grown, also curled as they feed, lie around; while beyond are the recently laid eggs, which I have had the honour of discovering may be the subject of the disease even before they leave the body of the mother.

Most careful microscopic examination is needful to

make the latter fact apparent; but the larvæ, on the contrary, so change in appearance soon after infection, that a practical eye at once detects the presence of the pest. Whilst healthy, their bodies are of a beautiful pearly whiteness, and their skins are tense with fulness; but where the disease strikes a larva, it moves uneasily in its cell, often then presenting the dorsal surface, as shown at A, Plate I., which well delineates a comb in a bad condition. Mere posture is thus no insufficient evidence of an unhealthy condition. The colour now changes to yellow, or the faintest buff, distinguishable immediately in a healthy brood-patch, which is, normally, perfectly even in tone. The colour strengthens to a pale brown, whilst the skin becomes flaccid and opaque; death soon occurs, when the body, shrunken by evaporation, lies on the lower side of the cell, becoming progressively darker, until it almost assumes the colour of coffee; desiccation continuing, in a few days nothing more than a flattish, black scale remains. In an infected stock, these can be seen in number by looking over the comb, having its upper edge towards the face of the observer.

Should the larva escape contamination until near the period of pupahood, it is sealed over in the normal way. The cover furnishes a screen, on which part of the cocoon is soon after spread; but the inhabitant of the cell is marked out for death, and before very long the capping or sealing sinks, becoming concave, and in it punctures of an irregular character appear (A, Plate I.), which is nearly a conclusive sign of the diseased condition of the colony.

The sense of smell is also appealed to, as a peculiar foul and extremely characteristic odour now escapes from the diseased combs. This is difficult to describe, but it reminds me of offensive glue; while it is not unlike that from guano. The odour is not always present with equal intensity; sometimes it is only observable when the hive is opened; at others, it is quite pronounced, even 3ft. or 4ft. from the entrance. As the disease spreads, the bees lose energy, but in most cases become unusually earnest in fanning at their hive door. Dead larvæ or pupæ, in growing numbers, occupy cells that should have been vacated to receive eggs, and, being irregularly scattered, force the latter to be distributed unmethodically, and not as in a healthy stock. Should any attempt be made at removing a dead larva which has assumed the coffee-coloured stage, the remains, tenaciously adhering to the cell wall, will stretch out into long and thin strings, somewhat like half-dried glue. The microscopist can easily explain this. The thin, chitinous, ærating sacs and tracheæ (page 33, Vol. I.) do not undergo decomposition at all easily, and these remaining occasion the peculiarity referred to. The disease is terribly infectious, and, once started, soon spreads from cell to cell, and not infrequently from stock to stock, until, in the whole apiary, perhaps not even one escapes.

Some of the symptoms described may appear in the absence of disease, when the brood has died from chill; but then the characteristic odour is absent, and the discoloration in the larvæ is usually a change to a grey, and not a brown. The microscope immediately

detects the difference, for if a speck of the interior of a larva, dead through cold or neglect, be placed on a glass slip, covered down in the usual way, and then examined by a good $\frac{1}{2}$in. or $\frac{1}{4}$in. objective, the field will be well-nigh covered with fat and other cells, not looking very unlike those taken from a healthy larva, as at B, Plate I. Although the descriptions given will enable the bee-keeper to pronounce pretty certainly upon the presence of foul brood, cases do occur in which nothing but a microscopic examination will settle the point beyond the possibility of doubt.

Before discussing the nature of foul brood, it is necessary to give some attention to the before-mentioned micro-organisms, to the presence of which is due, not only infectious diseases, but also all fermentive and putrefactive changes. To them the general name of *Schizomycetes*, or fission fungi, has been applied, because their method of increase is by splitting, or fissuration. They are divided into four genera: *Micrococcus, Bacterium*, *Bacillus*, and *Spirillum*. There are many species of each, and they may be classed as septic, or causing putrefaction; zymogenic, causing definite chemical changes, as lactic fermentation in the souring of milk; chromogenic, or colour-forming, because in masses they bear certain distinct tints; and pathogenic, or disease-producing; and it is here vital to note that those organisms only which are capable of growing and multiplying in the tissues of an animal are pathogenic to that animal, their presence immediately establishing a diseased condition. Other organisms, even if artificially introduced into healthy tissues, suffer rapid destruction.

Confining our inquiry within the narrowest possible limits, we have to do with pathogenic micrococci and bacilli, the former being minute, globular bodies (D, Fig. 123), which, at intervals, become slightly elongated, and then show a compression at what may be called the waist, giving them the form known technically as the dumb-bell. The compression becomes more pronounced, until, by separation, two tiny globules are produced from the one; each of these will, in turn, divide, and so multiplication may go on at an astonishing rate. Bacilli, on the contrary, are rod-shaped (B and C, Fig. 123); and if we could suppose a common ruler to elongate without increasing in thickness, and then, at a definite point, break into two, to again increase in each part in like manner, we should have a fair idea of the question. But sometimes this increase in length is not accompanied by separation, so that a line of bacilli may be formed comparable to a long string of sausages; and such is denominated a leptothrix (C, Plate I.). Under certain conditions, however, the bacilli produce spores, or seeds (E, Fig. 122), which the micrococci never do; while, in addition, bacilli are provided at their extremities with wondrously delicate filaments (B, Fig. 123), called flagella, which often defy detection, and are never seen but by the most skilful use of the finest microscope. With these they strike the fluid containing them, and so swim, much as a fish does by the use of its fins.

Taking a speck of the tenacious, coffee-coloured matter previously mentioned, and placing it upon a glass slip, adding water, and then a cover-glass (an

exceedingly thin circle of glass, about $\frac{3}{4}$in. in diameter), and making an examination by a $\frac{1}{2}$in. objective, or any higher power, we find it to contain countless swarms of very minute bodies, which dance in the field with a lively Brownian movement. Magnified 500 diameters, they appear as at E, Plate I.

These, before the investigations I made in 1884, were known to be associated with foul brood, and were supposed to be micrococci, in consequence of reported experiments made in Germany some years before by Dr. Schonfeld, of whose account space will only permit a very short summary. He states that, having procured some foul broody matter—*i.e.*, the brown material just referred to—he, by a simple contrivance, aspirated air, which he passed over the foul broody mass, through cotton wool, which then he found full of micrococci. He adds, that this cotton wool being spread over the cells of a comb in which larvæ were advancing, the latter took the disease, and died with their bodies filled with micrococci; and that lastly, having infected larvæ of *Musca vomitoria*, they not only died crammed with micrococci, but these micrococci communicated foul brood to previously healthy larvæ in the bee-hive. These experiments were accepted as so conclusive and satisfactory, that for ten years they were quoted as authoritative; but many observations, which could not be reconciled with commonly-received ideas respecting this malady, induced me, in 1884, to accept an invitation to address an International Congress of Bee-keepers on the subject, and to attempt to repeat Schonfeld's experiments, with such additions or modifications as might seem most suitable to my purpose.

This attempt has left me in intense bewilderment so far as any possible explanation of the causes of the errors into which Schonfeld undoubtedly fell. My results showed that in foul broody matter no micrococci necessarily existed, but that the minute bodies (E, Plate I.) found in the coffee-coloured material, which Schonfeld had erroneously taken for micrococci, were really spores of a bacillus, which neither he nor those who had preceded him had ever seen, although one of them does apply the name bacillus to the spore—because the spore is a long oval (*f*, E, Fig. 122), and so would resemble, *e.g.*, my *Bacillus Gaytoni* (G, Plate I.); and, further, that the disease could not be at all easily communicated to *Musca vomitoria*, while every dead larva of this fly contained innumerable micrococci; and that, when bee larvæ were artificially infected with foul broody matter, the bacillus nature of the disease was incontestable, while no micrococci, and not even the bacillus spore, which Schonfeld had taken for a micrococcus, could be discovered.

The process of staining is of enormous value in such an investigation as that now under consideration, and is given for the benefit of those who may desire to follow it. The juices, or substances to be examined, diluted with water if necessary, are, in minute quantity, flattened between two cover-glasses, which are separated by a slipping movement, so as to leave the thinnest outspread film. The cover, when the film is dry, is held by forceps, and quickly passed two or three times through a spirit flame, so as to set the contained albumen, and save the

material from being displaced by after-washing. The processes of staining are extremely varied, but the most simple, which is also one of the best, is here all-sufficient. A watery solution of the aniline dye called methyl-violet is placed in (preferably filtered into) a little saucer, when the cover, film downwards, is set swimming upon its surface. After from two to twenty minutes it is lifted, and thoroughly washed in water, to which, if the staining is too strong, a little alcohol or acetic acid may be added. Failing methyl-violet, red ink—*i.e.*, eosin and water—may be similarly used. The stains adhere more tenaciously to the micro-organisms than other matters present, and so the former are seen far more clearly than in their native, colourless condition. The preparation is now ready for examination, either wet or fixed down by Canada balsam, in the usual way.

Proceeding in the manner described, the juices of a healthy larva present, as already hinted, the appearance of B, Plate I. Fat-globules are numerous, whilst here and there we note the large, white, blood discs, and scattered throughout may be seen minute, globular particles (smaller than the bacilli spores), continually agitated with a Brownian movement. In the coffee-coloured matter, on the contrary, we find neither fat-globules, blood-cells, nor molecular base, but observe, amidst the remains of broken-down tracheæ, the field crowded with small, ovoid bodies—spores (the micrococci of Schonfeld), as at E, Plate I.; but if we have successfully applied our stain, we shall possibly discover a few undoubted bacilli, some of which are visibly passing into the spore condition.

The absence of dumb-bell forms, and the distinctly oval shape of what I presently found to be spores of the associated bacilli, at the first arrested my attention. Now, possessing myself of an infected stock, so that the course of the disease could be traced, I submitted the body of a grub recently dead to the scrutiny of the microscope, and here I was delighted by seeing hundreds of bacilli actively swimming backwards and forwards, and worming their way amidst degenerate blood-cells and fat-globules, as seen at D, Plate I.; while some of these bacilli had already begun to sporulate, as may be traced by a central enlargement. Securing other larvæ of suspicious colour only, I discovered that, at the incidence of the attack, the bacilli do not break up, but grow in thin chains (leptothrix), as at C, Plate I.

The examination of a larger number of larvæ, not only from the stock referred to, but from combs coming from various parts of Great Britain and Ireland, showed most conclusively that each individual affected contains in its blood bacilli of an average length of $\frac{1}{6000}$ in., and diameter of $\frac{1}{40000}$ in., mostly swimming with a corkscrew-like movement,* the termination of the rod, as seen in end view, constantly describing a small circle; that when the disease is establishing itself, leptothrix forms are common, some of them even reaching $\frac{1}{100}$ in. in length; that these then break up into bacilli, which rapidly multiply, so as to crowd the fluids and tissues, as may be judged from an exact drawing of a tiny blood

* I have only recently obtained sight of the flagella (B, Fig. 123), by which the movement is caused.

streak (F, Plate I.); that as the fluids of the grub fail, by loss of fats and albuminoids, the bacilli begin to swell centrally, as at *b*, *c*, *d*, E, Fig. 122, drawing the mycoprotein from their extremities, and thus gradually become spores; that after the death of the grub, and during the assumption of the viscid-putrid condition, this constant alteration of bacilli into spores continues; that after removal from the hive, it goes on so rapidly, that in a day or two scarcely a bacillus, as such, is discoverable, whilst the spores are innumerable; and, in addition, that a very cautious preparation of some broken-down viscus will show that the bacilli and spores arrange themselves in a most singular line fashion, as seen at F, Fig. 122, traces of which are visible at E, Plate I.

As might have been imagined, in an attempt at repeating Schonfeld's experiments, the supposed micrococcus did not multiply, but immediately disappeared, by conversion into the bacillus.

The somewhat extensive literature of this disease had always gone on the assumption that it affected larvæ, but larvæ only. This position did not appear to me to agree with many facts I had observed; *e.g.*, we may take away two or three combs, containing 5000 larvæ each, from a stock, and it will continue to progress pretty much as though it had lost nothing; while, if foul brood attacks it, and kills, say, 1000 of its grubs, it, as a rule, very perceptibly diminishes in strength. The only theory that appeared to me as satisfactory, was that the adults also die with the disease, but that, according to a necessary instinct, they leave the hive, and finish their course alone.

This theory was fully borne out by examination. Snipping off the end of the tongues of bees from diseased stocks, and then squeezing them so as to express blood, gave material which was found laden with bacilli, in most cases. Bees, however, if far gone, are almost bloodless, while the air-sacs, expanding as muscle vanishes, seem to fill nearly the whole interior cavity. This discovery was pregnant with consequences, and bee-dealers and others who, in ignorance of the facts, had always proclaimed that swarms were incapable of being affected by it, and that queens could never communicate it, had now to be told that this error had, in all probability, been no small part of the reason why foul brood had grown to a veritable pest.

Continuing the investigation, I proved that a large proportion of imago workers and drones die of this disease if they are raised in infected stocks, and that this explained the dwindling in numbers in any colony from the commencement of the attack. But, further, if workers and drones were liable, why might not queens be so likewise? and if this be possible, might we not get a solution of certain peculiarities with which bee-keepers of experience are familiar. *E.g.*, some months earlier I had imported a few queens from Italy, one of which had been inserted into a stock, which quickly after developed foul brood, while the queen lived only six or seven weeks. In addition, if the queen might be infected, why not the egg? In the case of pébrine, this had already been proved to be the case. The bee's egg is, to the size of the bacillus, enormous. Its length of $\frac{1}{14}$in., and diameter $\frac{1}{70}$in., would enable

it to accommodate 100,000,000 spores of this organism, which stands to the egg itself as a single drop to 1500 gallons. Following this line, and knowing that foul brood had in some cases appeared to be more particularly destructive amongst the smaller larvæ, I not unnaturally judged that, possibly, in these cases the egg contained the germs of the disease at the time of deposition. I communicated my suspicions to several owners of large apiaries, explaining what would be the probable peculiarities of genetic foul brood, if such a form really existed. Mr. Hart soon after sent me a queen from a hive which presented the indicated symptoms—viz., the early death of the larvæ; the earnestness of the bees in attempting to raise a new queen, although their number was so small that swarming was out of the question—this earnestness seeming to indicate that they were conscious of some unfitness about the mother, which they desired to remedy by displacing her; and lastly, a continuance of their hospitality to drones at a period of the season when other stocks had destroyed theirs.

The queen was alive at her arrival, and I forthwith began a careful dissection. Having removed the left air-sac, which lies within the first and second abdominal rings, and which was very much above the average size—a constant indication of the presence of bacilli—I came upon the ovary, of which I had previously removed many dozens. This one was abnormally yellow, and very soft, so that it was difficult to detach it from the larger external tracheæ without tearing; but a separated ovarian tube, placed under a second microscope, magnifying 250 diameters, at once

showed four or five bacilli, swimming along with a lazy sort of progression. Detaching now a half-developed egg, and crushing it flat, nine bacilli were quickly counted.

This was not an isolated case. Queens from badly-infected stocks are frequently themselves diseased, and, amongst the very large number I have had the opportunity of examining, some most interesting examples have presented themselves. In one, the spermatheca (page 224, Vol. I.) contained no spermatozoa, although the queen was young and had mated, since she had produced worker bees; but the spermatheca was filled with a dirty fluid, through which were scattered innumerable minute and irregular granules, amongst which swam large numbers of bacilli. Here, then, was a distinctly localised attack, which left the adjacent ovaries still in perfect health; and a question of some difficulty presents itself. The disease seems always acute in the larvæ, embracing all parts of their organisation. This may possibly result from the thinness of their membranes, the freedom of their viscera, the frequency of invagination, and the rapidity of interstitial changes in their case. In the imago, on the contrary, the disease assumes a chronic character, and, confined to a portion of the frame, at least temporarily, may be several weeks, and possibly, in queens, even months, in running its course.

The name foul brood, given in ignorance of the nature and scope of the malady, is manifestly utterly inappropriate. To say that a queen is suffering from foul brood is clearly ridiculous. The name *Bacillus alvei*, which I proposed, is now passing into

general use in England and America, and on the continent of Europe.

Bacillus alvei, running riot amongst the spermatozoa, either because a bacillus has been accidentally introduced into the vulva at the time of mating, or because the drone himself was infected, offers a curious subject for speculation. That the bacilli in some way affect the vitality of the spermatozoa, I have had abundant opportunity of witnessing, and have strong ground for supposing that if these, devitalised, are passed into the micropyle of the egg (page 231, Vol. I.), they, whose function it is to differentiate the sex, only partially complete their work, and hermaphrodites are produced.

The evidence as yet given that *Bacillus alvei* is the cause, and not a consequence, of the disease, might be regarded as conclusive; yet science rightly demands further corroboration, which is supplied by what is called cultivation and re-introduction. Let me now divest the process of cultivation of every non-essential, so explaining it that any, with most trifling cost, may follow the experiments given. The plans detailed in the text-books are more elaborate, but are not really better, as I can testify from following both. Those desiring the more usual methods may consult Dr. Klein's "Micro-organisms in Disease" or Dr. Crookshank's "Bacteriology."

The banishment of micro-organisms would clearly prevent those changes which are the direct result of their presence—viz., fermentation, putrefaction, and zymotic diseases. *E.g.*, milk sours through the multiplication of a germ; if the milk be boiled in a

flask plugged with cotton wool, the active organisms are killed, and the air, returning through the cotton plug, as the steam condenses after removal from the fire, has the germs *it* may contain strained out of it. The milk would probably (not certainly, for a reason presently evident) remain good for an indefinite period, and would be called "sterile"—*i.e.*, devoid of germs. If a single *Bacillus alvei* could now be transferred to this milk, the bacillus would multiply, and we should have a cultivation. But milk is opaque, contains fat-globules, and is in many ways unsuited to purposes of investigation; we therefore proceed thus: As the cotton wool is likely to become a source of contamination, the germs in it are destroyed by placing it, in a tin box, in the kitchen oven, and giving it, for about an hour, heat enough to very faintly discolour it. Test tubes, about 6in. by $\frac{1}{2}$in., are, after careful washing, similarly "ovened"; and now the cotton wool is fitted into their necks, making plugs tight enough to hold well in, $\frac{3}{4}$in. deep (*p*, C, Fig. 122). The ovening process it is now desirable to repeat; but it may be omitted. A transparent, nutrient jelly is made by chopping finely $\frac{1}{2}$lb. lean and very fresh beef, soaking it in 10oz. of water twelve hours, and straining carefully, pressing the meat as dry as possible. Now add half a salt-spoonful of salt, and a bare ounce of the best transparent gelatine;* then heat cautiously until the boiling point is reached (taking care that the gelatine is not burned). A little technical matter must here receive attention.

* $\frac{1}{8}$oz. of peptone (*Peptonum siccum*) would improve the medium, but may be omitted.

The material is now, probably, acid, and in it *Bacillus alvei* would not, on this account, grow; a solution of common carbonate of soda therefore must be added cautiously, constantly testing with fresh scraps of red litmus paper,* until its red colour begins to become purplish. Now clarify with white of egg, in the cook's way, and strain through muslin. Transfer the medium to the tubes through a narrow-necked funnel, so as not to soil the sides, filling each to the depth of 1½in. or 2in. (*gl*, C, Fig. 122). Carefully hold the cotton plug, with the fingers, at its exposed end only, and re-insert immediately. So soon as the tubes—which must be kept upright, lest the fluid touches the cotton—are filled, they are stood up in a saucepan containing some water, and boiled for an hour, then allowed to cool, and similarly re-boiled next day. Henceforth they will keep, without change, until the gelatine has completely dried up, for the obvious reason that all germs have been destroyed. These tubes are valuable stock, and may be used for the cultivation of any germs found during our searchings. A damp, cool place, in which they should be covered carefully from dust, is best for storing them. With indiarubber caps over the cotton wool, they may be preserved, ready for use, for years.

Four or five inches of moderately fine platinum wire, called a needle, and fixed by heating into the end of a thin glass rod, completes our apparatus. Having found a bee suffering from bacilli, we pass the platinum wire through a gas or any other flame, heating it to

* Books of this can be bought of the chemist for about 2d.

redness, to sterilise it. It immediately cools, when we, having first passed the end of the cotton plug through the flame, to burn off any germs resting upon it, hold our tube to be inoculated mouth downwards, touch the needle upon the diseased material, withdraw the plug, and carry the needle upwards through the gelatine; the bacteria upon the former are left behind, the plug is immediately re-inserted, and in a few days colonies of bacteria will be observed growing in the needle track. With *Bacillus alvei*, Mr. Watson Cheyne and myself found a most extraordinary arrangement of the colonies, which has marked off this bacillus as not only new to science, but one of quite peculiar interest. The colonies, after four or five days' growth, are seen as little, whitish, opalescent, globular masses, each containing, probably, many million individuals; but the bacilli soon break off from these, apparently in search of nutriment, and, liquefying the gelatine they touch, form fluid tracks, through which they swim, and establish at length sub-colonies at a distance. While many bacilli resemble *alvei* individually, the colony form is characteristic, and distinguishes it from every other. The progress made during twenty-four hours may be judged by drawings of a single tube, as seen at noon on two consecutive days (A and B, Fig. 122). If these bacilli are growing on a flat surface, their behaviour is almost fantastic. An actual form, from a sketch, is given at G. As the nutriment contained in the medium becomes exhausted, the bacilli, as in the body of the bee, begin to pass into the rest or spore condition, showing the forms *a, b, c, d, e, f,* E.

Some of the spores from the first tube, being now

carried by the needle, as before, into a second tube, the spores germinate, bacilli developing within, breaking the capsule, and escaping as seen at *g*, *h*, *i*, *k*, *l*, *m*, D: multiplication by fissuration now occurs about every twenty minutes. If the tubes be inoculated in succession, it is evident that everything drawn from the

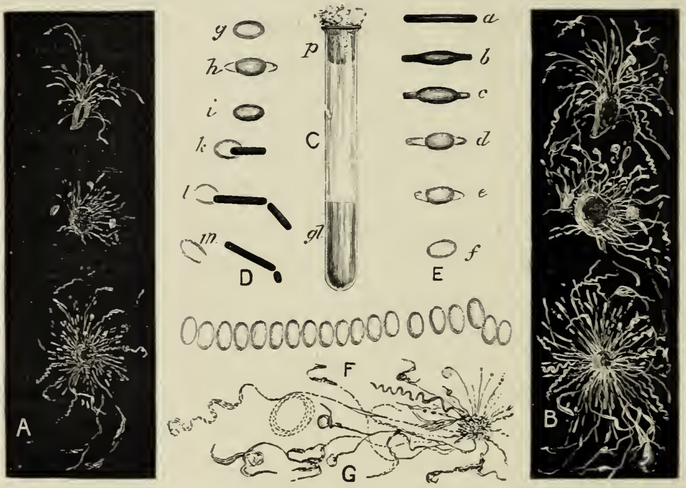


FIG. 122.—BACILLUS ALVEI UNDER CULTIVATION.

A, Colonies of *Bacillus alvei* under Cultivation (6 diameters). B, Same Colonies Twenty-four Hours later. C, Culture Tube (Scale, ¼)—*gl*, Gelatine; *p*, Plug. D, Spore becoming Bacillus (1800 diameters). E, Bacillus becoming Spore. F, Spores in Line from a Culture. G, Colony Spreading (50 diameters).

bee whence the virus was taken will be quickly eliminated, the bacillus excepted. Twelve tubes were thus cultivated in series in the Biological Laboratory, Kensington, and then a culture was made in milk from the last. Some of this, containing countless bacilli, I sprayed over a comb of young larvæ, part of which I screened by a cardboard having four large lozenges

cut in it. Those exposed to the spray were in part removed by the bees; the rest died, passing through all the changes observed in foul brood (*Bacillus alvei*), and were found full of bacilli; while the screened larvæ matured in health, proving incontestably that the bacillus is the *cause* of the disease. This is further corroborated by all the cultures giving off the exact odour of an infected stock.

Two other characteristics of this particular bacillus need mentioning: First, the extraordinary and unique size of the spore, which is about $\frac{1}{23000}$in. wide and $\frac{1}{12000}$in. long. These, when stained, if examined by a first-class $\frac{1}{10}$in. or $\frac{1}{12}$in., can be measured and identified immediately after removal from the body of the bee, or when found in coffee-coloured material. It is thus that *Bacillus alvei* can be pronounced upon at once. The second peculiarity is observed when the cultures are made in agar agar, when the spores are formed in line, as at F, Fig. 122. As already remarked, they also lie in this order in the tissues of the insect; but to display them thus requires great address and much patience.*

We have now to consider the means of propagating the disease. It has been confidently asserted that the honey is the seat of the contagium, and that bees carry the disease into their hives by robbing. Of course, this positive assertion has no better proof than the equally false supposition that the disease only

* For further information, see the "Pathogenic History, and History under Cultivation, of a New Bacillus (*Bacillus alvei*)," by Frank R. Cheshire, F.R.M.S., F.L.S., and Watson Cheyne, M.B., F.R.C.S., &c. (*Journal of the Royal Microscopical Society*, August, 1885).

touched the brood. The honey, we have been told, abounded with micrococci, whereas none are to be found in it; while I have searched most carefully in honey in contiguity with cells holding dead larvæ, have examined samples from stocks dying out with rottenness, inspected extracted honey from terribly diseased colonies, and yet in no instance have I found an active bacillus, and never have been able to be sure of discovering one in the spore condition; although it must be admitted that the problem has its microscopic difficulties, because the stains used to make the bacilli apparent attach themselves very strongly to all pollen grains, and parts thereof, and somewhat interfere with examination. I have now discovered that it is *impossible* for bacilli to multiply in honey, because they cannot grow in any fluid having an acid reaction. I have prepared tubes of gelatinised meat-juice, omitting to make them alkaline. The bacilli will remain in such for months without sprouting. If, now, a fraction of a drop of ammonia be placed on the surface of the gelatine, the ammonia will gradually transfuse into the gelatine, and impart the necessary alkalinity. Immediately the dormant bacilli commence to grow, and form colonies. Such minute bodies as bacilli, produced in inconceivable numbers in the hive—a dead larva containing frequently 1,000,000,000 spores — must occur in honey as an occasional contamination; but the idea that they grow in the honey is quite contrary to all evidence. Of course, since the manipulator can scarcely visit a diseased stock without getting numbers of the bacilli upon his fingers, the bees cannot perambulate the

combs without bringing their pulvilli (page 124, Vol. I.), and the hairs of their bodies, into dangerous contact with them, and so the visits of robbers are likely enough to result in infection of the stock whence they came, while the honey would, by its adhesiveness, aid in carrying away the terrible spores.

A large number of observations has clearly shown that the disease, in the larva at least, is not one of the digestive tube, but of the blood, and, through it, of every viscus. If honey were the means of communicating it, certainly traces of it would be found in the alimentary sac; but here I find the bacillus only very occasionally. In the adult bee, however, although the disease fills the blood, it is still very prominent indeed in the chyle stomach. The nurses in the hive are, with little question, the main means of infecting the larvæ; travelling in the darkness, they become aware of the needs of the occupants of the brood-cells by constantly inserting their antennæ, which must, where disease reigns, be brought into contact with bacilli. The transfer of these to the next grub fed will there start the disease. It is also extremely likely that spores are carried in the air, and taken in by the in-draught set up by the fanners. There will be no difficulty in this supposition when it is remembered that these organisms are so minute that a cubic inch of material would form a quadruple line of them from London to New York. Ordinary dust motes are, to such, huge by comparison; so that the means by which they are disseminated must be altogether too varied. In the royal jelly of the queen pupa dead of bacillus, I could discover no

bacilli, nor have I succeeded better with the food provided to worker larvæ; so that, although I would not dogmatise, my strong opinion is that, commonly, neither honey nor pollen carry the disease, but that the feet and antennæ of the bees usually do. In a somewhat different malady, *Empusa musci* of the house-fly, the germs are known to take effect by settling on the spiracles, or between the abdominal rings, and the spiracle of the bee, in all its stages, may be the especially vulnerable part.

The bee-keeper is, unfortunately, almost compelled to become himself a probable cause of infection. His hands, made adhesive by propolis, carry the spores or bacilli, and so may transfer them, even hours later, to healthy hives. The clothes should be kept, as far as practicable, from contact with suffering colonies, and the hands, after manipulating them, should be disinfected by washing with a weak solution of mercuric chloride (corrosive sublimate), $\frac{1}{8}$oz. in one gallon of water being quite strong enough. It must be remembered that this drug is a violent poison, and the solution should be kept in a bottle, so that a little may be just poured over the fingers, and then distributed over the hands, which may afterwards be washed in the usual way. The solution, at the strength given, will not injure the skin, and is the fluid used in laboratories for the purpose given, where deadly germs are in cultivation. *Bacillus alvei* is not harmful to human beings, even if applied to wounds.

Our third head now demands our attention. In what way can we most successfully, if at all, treat and eradicate this pest? Although ever an earnest advocate

of curative measures, I am yet at the outset constrained to say, that the disease is so sadly infectious that those who are by nature apathetic, or whose occupation will only permit half attention to their bees, may inflict grievous wrong upon their neighbours by attempting any cure, as this is likely to be done in a fitful, negligent fashion, keeping the disease languishing, while other stocks are, through it, being made victims. To such I advise, as the kindest course to self and others, the destruction by fire of the combs, and, possibly, even the frames and hives. If the bees are worth saving, make a swarm of them into a skep, and transfer forty-eight hours later into a frame-hive. If there be much brood, the case not a very bad one, and the robbing season not at hand, unqueen, cutting out all royal cells eleven days later, and giving from a healthy stock a royal cell just sealed. When the queen hatches—by which time nearly all the worker brood will also have left their cells—make a swarm of them into a skep, and transfer, on the second day, into a frame-hive. The queen will, in seven or eight days, begin to lay, and probably all will go well. The re-queening removes the possibly infected queen, and gives in her place a healthy one, while the delay gives time for the diseased bees to die off before they are required to act as nurses, which is the virtue of the so-called "starvation cure." The honey in the diseased combs may be melted down, thinned with water, boiled, and used as food, preferably with medication.

The destruction of the hive, however, is never *necessary*, for, after the worst cases, it may be used

again with perfect safety if, having been washed* and dried, it be scrupulously painted with a mixture of two parts methylated spirit and one part carbolic acid crystals, or one-and-a-half parts good white fluid carbolic acid. This mixture not only rapidly destroys all bacilli and spores, but it glues them down into place, by dissolving the propolis, and insinuating itself into every cranny. Other methods are at command, Mr. R. Sproule having contrived a disinfecting apparatus, which he finds perfectly efficacious; by it he vaporises carbolic acid in steam, which is carried through the carpeting by a pipe. The processes of ovening, or prolonged boiling, will also, from what has been said on sterilising, disinfect the hives and frames. The oven of the kitchener will usually be large enough to receive the latter, and so can render them re-fit for use. I believe, for hives, the process of painting with my mixture, now recommended, will be found most generally useful; but let none depend on a hope that the spores will die by simply leaving the hive empty for a season. I have just tried some of these spores kept sixteen-and-a-half months in a glass tube, and exposed on several occasions to a temperature below frost. Upon introduction into gelatinised meat-juice, they immediately started growing.

The old German plan of giving salicylic acid † in food, and spraying with a $\frac{1}{150}$ solution of the same,

* For the washing, the corrosive sublimate solution (page 558) may be used with advantage, but thorough rinsing must follow.

† For further information, see the Address of the Author: "Foul Brood not Micrococcus, but Bacillus—the Means of its Propagation, and the Method of its Cure" (*British Bee Journal*, Vol. XII., August 12, 1884).

I found, many years since, effectual, but necessitating much care and prolonged attention. Those advocating salicylic acid, now recommend its use in a fumigator, as devised by Mons. Bertrand. This apparatus, which looks like a small still, contains a spirit lamp, the flame of which rises beneath a metal dish. Surrounding the latter is a cylinder of stout tin, covered by an inverted funnel form, the neck of which is bent to the horizontal, and made in cross section an oblong 5in. by $1\frac{1}{4}$in. The hive is raised from its floor-board until the mouth of the funnel passes in at the entrance, and the corner of the quilt is lifted to permit a free circulation of the vaporised acid, 1 gram (= $15\frac{1}{2}$ grains) of which is placed in the dish, over the burning lamp. Every portion of the hive is reached by the vapour; and when the fumigation is repeated every few days, in the early morning, or late in the evening, so as to have all the bees at home, under its influence, it is said to be very effective. It is singular that salicylic acid at 220° C. is converted into phenol and carbonic acid, and that to vaporise salicylic acid without this conversion is a delicate operation. Doubtless, therefore, the process given is likely to be more really fumigation by phenol, although, nominally, by salicylic acid. The objection seems to be in the extreme uncertainty of the amount of dose given by this arrangement.

The phenol treatment has been largely associated with my own name, because I originated a new application of an old remedy. My words at the Congress were: "About three years' since, Mr. R. Sproule, an Irish gentleman of culture, mentioned to me that he

had used phenol in the treatment of foul brood with a good deal of success. I replied that I would seek opportunities of experimenting, and, if I found the result advantageous, I would, as I am always glad to do, mention his name, with thanks for the suggestion." The suggestion, as I now know, was not novel. But the way of utilising the remedy had not yet been discovered, and Mr. Sproule, with it in his hands, for want of noting the way of giving it, lost a large part of his apiary. His plan was to feed with syrup, into which he put a small quantity of Calvert's No. 1 phenol, or carbolic acid; but Ligurians refused the food, and succumbed to the disease. Striving to keep to my expressed intention of seeking opportunities to experiment, I, up to the close of 1883, found and treated six stocks, with results that convinced me that, with proper management, I had a remedy beside which salicylic acid was but vexation of spirit. Old experience with the latter drug had shown me that the system of spraying was chilling and depressing, and that medicine and food should, if possible, be given together. We thus get a constant quantity, as every grub must receive the same amount of nourishment; and if we have a curative agent, and have ascertained the dose, the difficulty is accomplished.

"To place the food, with added phenol, on the hive, will, however, do nothing* in the greater number of cases. If honey be coming in, the bees will not

* These are the very words I used in my Address three years since; and yet many, with a perversity which is almost incredible, say that phenol will not cure, for they have given it in the food-bottle, but the bees would not take it.

touch it; but open the stocks, remove the brood-combs, and pour the medicated syrup into those cells immediately around and over the brood, and the bees *will use* a curative quantity of phenol." In my experiments I inoculated a stock, and allowed it to get into a bad state, then inserted a comb of store in the centre of the brood-nest, and treated one side, from which the disease disappeared, but raged, although with abated fury, in the other half. Having, by these and many similar experiments, made the curability of *Bacillus alvei* a certitude, and having ascertained that $\frac{1}{400}$ of phenol could be given to the bees without limiting the queen in breeding, or touching her health, while $\frac{1}{500}$ dispatched the bacillus quickly when honey was coming in, and $\frac{1}{750}$ when it was not, I, in the interest of apiculture, requested the British Bee-keepers' Association to provide me with a bad case, fully attested.

It arrived late, June 21st, 1884, with seven combs, about half a pint of bees, and a queen-cell—which I saw at once contained a dead larva only. Amidst crowds of bad cells, scarcely any living brood was visible. A casual counting of one of the best frames gave 371 dead larvæ on one side. The odour was pronounced. The case needed confidence; it was bad indeed. With me, queenlessness presents the worst of all obstacles. No grubs, no physic, no cure! I had stipulated that the stock should have a queen, and so the difficulty was greater than I had anticipated. Early next morning, seeing the utterly disheartened condition of the poor bees, I went to a nucleus, took out a very fine Italian mother, just proved as purely fecundated, and putting her under a dome cage,

on a card, placed the card over the frames. The bees came up, and seemed to see in her a new hope. The cage was lifted, and she was welcomed immediately. I waited three days, till she was regularly laying, giving syrup phenolated 1 in 500; and now, since I could not create bees, added two combs of brood. This step was made necessary by the fact that I required a strong hive by the time of the Congress. The bees were now shut up by a division-board; but the combs put behind it, waiting introduction as the bees multiplied, smelt so badly—the weather being hot—that I several times sprayed them with water 200, phenol 1. Now I should compress the bees as much as possible, and spray the removed combs freely with water 50, phenol 1. To return. Every evening the medicated syrup was given, by pouring around the brood-nest; but only so much as would be likely to be used, the object not being to fill the cells, but to get the food converted into bees. The smell vanished, the bees became active and earnest. The comb with 371 dead larvæ on one side was last added, and in six days I could only find five sunken caps in the whole of it. Now and again a grub took the disease, but quickly perfect immunity was the issue. No cell was uncapped, no diseased grub removed, nor the hive touched, except as described. The bees cleaned their floor and their combs; while, in four weeks and two or three days, every frame became filled with brood in the brightest and best possible condition. Since this, worse cases have succumbed in the same fashion. Abundant corroboration has been given from those who have

tried my method, and have succeeded, to their own delight, while some have failed; but the testimony is general, that bees under phenol become more energetic than are those that need no treatment.

The quantities are easily managed. 1 oz. of phenol crystals (= carbolic acid No. 1) will be sufficient for 40lb. of syrup, ¼oz. for 10lb., or ¼oz. of liquid carbolic, P.B., for 9lb. syrup, or rather less than three quarts. The carbolic acid should be added to the syrup when the latter is cool, and equally mixed by careful stirring.

Mr. McLain is just reporting some cures which appear remarkable, and, since I have no personal interest whatever to serve, I only trust that his method may be superior to mine, although it certainly involves much more trouble. I have used his remedy, and find spraying with a syrupy fluid very messy; but time is needed before one can judge of results. I give his recipe and treatment in his own words:

"To three pints of soft water, add one pint of dairy salt. Use an earthen vessel. Raise the temperature to 90° Fahr.; stir till the salt is thoroughly dissolved; add one pint of soft water, boiling hot, in which has been dissolved four tablespoonfuls of bicarbonate of soda; stir thoroughly, while adding to the mixture sufficient honey or syrup to make it quite sweet, but not enough to perceptibly thicken; to ¼oz. of pure salicylic acid (the crystal), add alcohol sufficient to thoroughly cut it (about 1 oz.), and add this to the mixture while still warm, and when thoroughly stirred, leave standing for two or three hours, when it becomes settled and clear.

"*Treatment.*—Shake the bees from the combs, and

extract the honey as clearly as possible. Then thoroughly atomise the combs, blowing a spray of the mixture over and into the cells, using a large atomiser, throwing a copious spray; then return the combs to the bees. Combs having considerable quantities of pollen should be melted into wax, and the refuse burned. If there is no honey to be obtained in the fields, feed syrup, or the honey which has just been extracted. If syrup is used, add 1 oz. of the remedy to each quart of the syrup fed; if the honey is used, add 2½oz. The honey and syrup should be fed warm, and the remedy thoroughly stirred in; and no more should be furnished than is consumed. Continue the treatment, by thoroughly and copiously spraying the diseased colonies, at intervals of three days, simply setting the frames apart, so as to direct the spray entirely over the combs and bees. In order to keep the bees from bringing in fresh pollen, burn old dry bones to an ash, pulverise in a mortar, and sift through a fine wire-cloth; and make a mixture of rye-flour and bone-flour, using three parts of rye-flour to one of bone-flour, adding enough of the syrup, or medicated honey, to make a thick paste. Spread this paste over part of one side of a disinfected comb, pressing it into the cells with a stiff brush, or a thin honey knife, and hang this in the hive, next to the brood. Continue this treatment until a cure is effected. Keep sweetened brine, at all times, accessible to the bees, and continue the use of the rye and bone-flour paste while the colonies are recuperating."

Microscopic examination of *Bacillus alvei* shows clearly that it is subject to variations in the vigour

of its growth—sometimes the rods are longer and stouter than at others; but its colony form is quite constant, and the spores, and the methods of their production, are always the same. In blood serum, this bacillus grows with even greater vigour than it does in the body of the bee. Variation, which will account for the disease being sometimes especially virulent, is commonly observed in micro-organisms, and forms the very basis of the system of attenuation for inoculation purposes as practised by Pasteur and others. Where the queen is diseased, probably no treatment will be efficacious until she has been replaced. This is a problem which seems to forbid solution, since we have no means of determining the condition of a queen until her life has been sacrificed. Those who believe that the replacement of the queen is all that is needed for a cure, will soon get evidence of their palpable error. Pricking a needle into a diseased larva, and then touching a larva in a healthy hive with it, is, five times out of six, enough to start a vigorous attack. It could not, however, be supposed that the queen is, in such a case, the cause of the malady. Summer is, without doubt, the best time for treatment, as then the bees can not only more easily bear the necessary disturbance and the chilling, but they can be aroused to rapid brood-raising, which involves the application of the remedy.

Bags containing camphor, placed within an infected stock, have been stated to work a cure. They probably are an advantage, and might be used in winter; but, in my own trials, *Bacillus alvei* has gone on developing and extending its ravages, notwithstanding

the presence of the camphor. The so-called coffee cure it cannot be uncharitable to regard as a mere silly whim, which does not deserve to be dignified by discussion.

General vigour in the colony is, possibly, some defence against an attack, for the cell life of the bacillus has to battle against the cell life of the bee, in order that it may convert the tissues of the latter into its feeding-ground. Thus, in consumption, the bacillus causing it may be held in check during vigorous bodily health; but a cold, or any lowering of tone, gives the bacillus a chance, and it multiplies, invading the lung; producing the "cheesing" so well known to the medical man. It is, on the other hand, however, untrue that mouldy combs, want of ventilation, dampness, or even chilled brood, cause an outbreak, for this can alone follow the introduction of the special organism from which the disease is always derived.

A considerable number of instances occur in which numerous undersized, hairless, and greasy-looking bees are found perambulating the combs, or are dragged, *nolentes volentes*, to the hive door, and then and there evicted. In other cases, crowds of these "abnormal" bees die immediately in front of their homes, while many are usually to be found running about upon the ground, constantly stopping to rub their legs, antennæ, and bodies, with a nervous, uneasy movement, and then, collecting into little knots, continue these convulsive twitchings until they die. This disease is commonly most destructive in the spring, but it may continue active throughout the year. The old explana-

tion, that these glossy, or "black bees,"* are robbers—old felons, indeed, which have so often been severely mauled in being driven from the communities they were plundering that all the hairs of their bodies had been pulled out—is clearly, for many reasons, inaccurate. These bees I find, in every case, filled with a bacillus (G, Plate I.) smaller than *Bacillus alvei*, and which cultures have shown to be quite specifically distinct. Its length is about $\frac{1}{15000}$ in., and its width

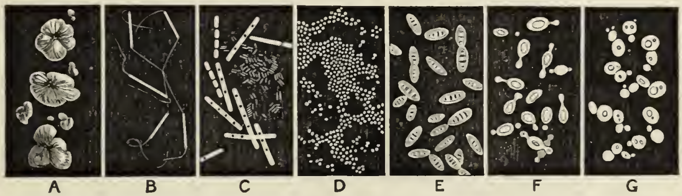


FIG. 123.—VARIOUS ORGANISMS FOUND IN THE JUICES AND TISSUES OF DISEASED BEES.

A, Colonies of *Bacillus Gaytoni* in Cultivation (Magnified 5 diameters). B, Bacilli (not *alvei*) found in Blood of Queen, showing Flagella (500 diameters). C, Bacilli found in Blood of Queen (Two Species, one very large), showing Spores (Magnified 800 diameters). D, Micrococci found in all the Tissues of a Queen (500 diameters). E, Organism found in Blood of Queen—the only discovered Example—not Cultivated (1000 diameters). F, Torula (?) found in Dysenteric Worker (500 diameters). G, Torula found in Dysenteric Worker (500 diameters).

$\frac{1}{35000}$ in., and it is often so short and rounded that it might be mistaken for a bacterium. Its colony form (A, Fig. 123) is very marked. Under cultivation, it slowly liquefies the jelly, producing a milky-looking mass at the top of the culture. When seen under a low power, the colonies have a singular kidney-like form, being distinctly lobulated, and appear brown under transmitted light. By reflected light they are

* So called because of the black appearance induced by the loss of the hairy covering.

opaline, and when magnified fifty diameters show that the bacilli are grouped in radiating clusters. These characters mark off this bacillus from other forms. I have named it *Bacillus Gaytoni*, from Miss Gayton, who found some of her bees suffering three years in succession as I have described, and at whose request I investigated the cause. Miss Gayton imagined the disease to be connected with the queen, and this I have been able to corroborate, as the queen, in these diseased colonies, abounds with these bacilli. What is more important, is that her removal, and the establishment of a healthy successor, usually banishes the unfavourable symptoms; but this is not uniformly true, seeming to show that the bacillus is readily communicable from bee to bee, the attack being at times immensely more virulent than at others. Weakness and loss of vitality, with defective nutrition, would seem to occasion the dropping of the hairs, and this is, no doubt, favoured by the uneasy scraping, to which the body of the sufferer is continually subjected. Very large numbers of bees, sent me from different parts, and one from Cyprus, have yielded this bacillus as the result of cultivation, and I have found it the very easiest to propagate. My experience in treating it is very limited, but some trying phenol have testified that very obstinate cases of it yield to the same measures as would subdue *Bacillus alvei*—by the side of which, be it remembered, it is a very slight offender.

In human diseases, as well as those of the larger animals, two or even more micro-organisms have been

found growing in the affected tissues. Bees often exhibit the same peculiarity; *e.g.*, at C, Fig. 123, we have a blood-stain from one of a number of bees sent by a correspondent,* in which a beaded (spore-bearing), large bacillus, is found growing side by side with a very small one. The large bacillus collects in dense plates (zooglea form), of many thousands, in actual lateral contact. Of the significance of this bacillus nothing is at present known, except that it appeared to be the occasion of a most destructive attack. Only two distinct instances of the occurrence of this bacillus have come under my knowledge.

The flagella of a bacillus found in a queen at Edenthorpe are peculiarly distinct; and an interesting example, picked out by my keen-eyed friend, Mr. E. M. Nelson, when looking over my collection, is seen at B, Fig. 123; here the flagella from two pairs of bacilli have caught, and are drawing each other tight.

In a large apiary, a queen of very unusual size, but with relatively small legs, was found to be too weak to continue on the comb, and was literally scarcely more than a bag of micrococci, the whole body being completely broken down. Upon touching her side with the point of the forceps, with the idea of commencing a dissection, a thin, milky fluid escaped in astonishing quantity. A trace of this, placed on a glass slip, appeared as at D, Fig. 123. No similar instance has come under my knowledge. A remarkable, and also, to me, unique, case is illustrated at E,

* Names, of course, could not be given without permission; but I have them attached to my collection for future reference.

Fig. 123. This strange organism was found in millions in the blood of a queen sent me, with a statement that, although not old, she was useless, as she scarcely laid at all. These organisms clearly multiply by fissuration, and carry a thick envelope, while within they have darker cross markings, exceedingly difficult to define.

A distinction—as stated at page 525—should be drawn between an overloading of the bowel with pollen residues, due to protracted cold in winter, and a condition of distension resulting from the presence and multiplication of fermentative germs. At F, Fig. 123, is represented an organism found in multitudes in the fluids of dysenteric, or, rather, diarrhœtic, bees, the bodies of which were tremendously swollen. The organism, under cultivation in a peptone and sugar medium, showed itself to be one of the phycomycetes, known by the produced mycelium* and its manner of fructification. The question is too technical to be followed here *in extenso*, especially as at present further investigation is necessary. Other dysenteric bees have contained a true torula (as at G), while their uncapped honey had thinned by alcoholic fermentation, and was frothing out with the underlying pollen from the mouths of the cells.

The catalogue of germs observed in bees is by no means exhausted, and I have now under experiment one which has recently presented itself in the apiary of the Rev. G. Raynor, which seems to be only second to *alvei* in destructiveness, and respecting

* See Sachs' "Text-book of Botany," Second Edition, page 266.

which it would be premature to give any details, beyond that phenol is certainly, to some extent, beneficial.

Finally, are these germs indicative of disease? Emphatically they are, in every case. Bacteria are *not* found in *healthy* tissues, nor in *healthy* blood; and, since I may be reminded of an editorial in the *British Bee Journal* of May 13th, 1886, which has somewhat confused the minds of some, I will simply give three references to the *Royal Microscopical Society's Journal*. June, 1886, page 536: "Pasteur's experiments have shown that the tissues of animals are the most perfect filters known, neither permitting the entrance, nor tolerating the existence, of any foreign material, unless the tissues are diseased." August, 1886, page 665: "Herr G. Hauser has subjected this question to fresh examination, with the following results: In the living tissues and tissue-fluids of healthy animals, he finds neither pathogenic nor any other description of bacteria." December, 1886, page 1036: "Herr J. von Fodor has examined the blood of healthy living, or recently killed, animals, for the purpose of ascertaining if bacteria develop. The blood, placed in sterilised flasks, with the usual precautions, was kept at the temperature of the room, or in incubators at 95° to 98° Fahr., for several weeks, and, after excluding errors from accidental impurities, the author found that the blood contained no bacterial germs capable of development.

"The author, furthermore, injected non-pathogenic bacteria in enormous quantities into the jugular veins of living rabbits, and found, in consonance with the

results of other observers, that the injected bacteria disappeared from the blood within a short time."

Space, however, forbids my replying to the whole article, the value of which may be gauged by one point. I had drawn attention to the wild assertion that, "at every breath, we are inhaling thousands" of bacteria, and pointed out that three bacteria per inspiration was the highest number ever observed, while one in eighteen inspirations was the average. For these *exact* statements I am soundly lectured; and, in order to convict me of error, a reference is made to Dr. Miquel, whom I had previously cited, and, to refute me, a supposed calculation is based upon his data. This concludes that every cubic inch of air at midday contains 825, and at 8 p.m. 16,500, bacteria —a deliverance positively comical in its extravagance. My censor has only mistaken a cubic metre for a cubic centimetre, and so his results are just one million times too great—a degree of accuracy which would argue that no single cell of honey should be sold for less than £40, and that a good queen should weigh one-quarter of a ton. It is possible, nay, probable, that Mr. Cowan did not go, as his article would have us suppose, to *La Semaine Médicale*, now lying before me, but to an abstract in the *Royal Microscopical Society's Journal*, as here a printer's error occurs; but this is unimportant, as either way it would appear incredible that any person having the least knowledge of the subject could have fallen for a moment into such errors, much less have made them the subject of a calculation, and an attack not conspicuous by its modesty. Culture tubes can be

opened many times without contamination. I have one still pure, over a year old, from which six dozen inoculations at least have been made. Would this be possible if *one* bacterium could be found, on an average, in each cubic inch? The actual average is one in about 650 cubic inches for the open; in thronged rooms it is much greater, the highest record, up to date, occurring during a *soirée* of the Royal Society, when, of course, the air was laden with foreign matter of every kind. Here Frankland found two bacteria in three cubic inches of air. Personally, I could have afforded to have allowed this criticism to pass, as I have done many others; but it would have been a failure in duty to have left it unrefuted—to hinder the spread of light upon a question of vast importance to the future of apiculture. Had the courtesy been reciprocated which I extended to the writer of the article in question when, at his visit to learn my methods, I presented him with a good number of my best preparations, I could have replied in another place. My trust is, that the presence of pathogenic organisms amongst our stocks will be regarded as a grave—an increasingly grave—matter, calling for the best efforts of everyone; for, unless the diseased stocks are either cured or destroyed, the mischief they work grows as bee-keepers multiply, and that in the ratio of the square of their multiplication.

The enemies of the bee found amongst the animal world are many, but their power for evil is as nothing beside the vegetable foes we have been considering—and so we may dismiss them quickly. Wax moths,

in Britain, are but little to be feared. Late in the summer evening, the moth may occasionally be seen flitting at the hive door, to gain access to the combs, on which to lay her eggs; but if the population be at all numerous, the guards give her but a small chance of effecting an entrance. Should she succeed, the eggs deposited on the combs will be at once ejected, unless the bees are so sparse as to leave them unvisited. Eggs may possibly hatch if left in unreachable corners, or on the *débris* collecting from wax plates dropped during comb-building and sealing; but here the little grubs only gain an existence by gathering up the fragments, that nothing be lost, and only where a colony is miserably weak, or has lost heart through hopeless queenlessness, can they work mischief among the comb. Here, if suffered to remain, they worm their way through the midrib, constructing a silky tunnel, on the walls of which will be found their dejectamenta, resembling grains of gunpowder, and by degrees the comb is utterly ruined; comb, therefore, in store may be destroyed by their ravages. The egg is but $\frac{1}{100}$in. in diameter, and so likely to escape detection. Should the characteristic flannelly line show itself, expose the whole to the fumes of burning sulphur, or fumigate thus as a precaution. The sulphurous acid produced quickly gives the quietus to the little tormentors. No further attention will be necessary, if we place the combs out of the reach of the moth, or if the season of her flight has closed, as eggs also are, at the same time, destroyed.

The death's-head moth (*Acherontia Atropos*) is an enemy of bees; but the statement that she can swallow

a tablsepoonful of honey is, of course, a mere fable. The bees would be able to prevent her entrance, but she is capable of emitting a stridulating note like that of the queen (page 157), which seems to terrify the inhabitants of the hive. They generally close with the enemy, however, after a time, and then every scale (feather) of the moth is pulled out, causing it to change its appearance in a most remarkable manner. I have a specimen from a hive near Lowestoft, which most persons would be unable to imagine could have been a moth at all. That

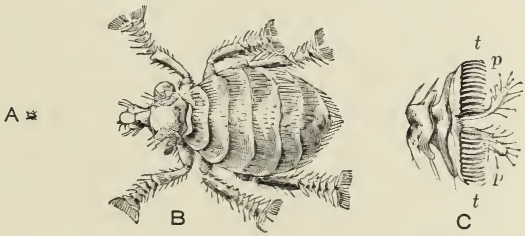


FIG. 124.—BRAULA CÆCA.

A, Braula (Natural size). B, Male Ditto, Magnified 18 diameters. C, Foot of Braula (Magnified 80 diameters)—*t*, *t*, Teeth; *p*, *p*, Pulvilli.

point is, however, settled by the nervures of the wings. The moth is very rarely found in hives, but the caterpillar is not uncommon on the leaves of the potato, and is extremely large.

The *Braula cæca* (A, Fig. 124) is a small, reddish-brown, wingless louse, parasitic on the bee, and of relatively large size, being about $\frac{1}{16}$ in. long. It is most generally found on imported bees, and rarely survives a winter in Britain. I found them, however, two years since, many hundreds strong, in each of several colonies of black bees, at Orpington, which I

visited because of this reported peculiarity. I removed twelve *braulæ* from one queen; and, strangely, if a very few only exist in the colony, the queen carries them, they, at least, seeming to believe in "royal blood," which they secure by means of a jawed sucker. They are exceedingly difficult to dislodge, as their movements are rapid, and as their bodies, furnished with beautiful hairs, are flattish; while their unique feet, each carrying two toothed combs (*t*, *t*, C), give them a secure hold of the webbed hairs of the bee. Touching them by a small brush, pointed with thick honey, will generally lift them from their place. Beneath each foot are two pulvilli (*p*, *p*), of exquisite beauty as microscopic objects; they are provided with knobbed, sensitive hairs, by which they feel the surface upon which they are resting. The name *cæca* implies that these creatures are blind; and this the female appears to be; the male also, possibly, but he has rudiments of eyes. The eggs sometimes hatch within the body of the mother. The larvæ pass through their changes in about fifteen days. The damage they cause, even if numerous, is not apparently serious. They are of great interest to the entomologist, who has been puzzled as to their classification; and they have recently been translated from the *Hippoboscidæ* to the *Braulidæ*.

The blue tit (*Parus cœruleus*) and the great tit (*Parus major*), during prolonged cold, are often reduced to extremities, and then they are too ready to make a meal of such members of our stock as they may chance to pick up by waiting at a hive door. The idea that they take drones only is inaccu-

rate, since they hunt most when drones do not exist. To these birds we must add the fly-catcher and the chaffinch, and, amongst other less offenders, the sparrow, which I have seen to take bees when on the wing. Some of these birds remove the stings, an interesting collection of which was found by my late friend, Mr. John Hunter, on a rail, after a blue tit had been dining at his expense.

The toad I have known to fatten amazingly while skulking beneath a hive, its lightning tongue causing hundreds of over-fatigued labourers to disappear, as they have dropped into a tangle of weeds, affording too good a covert for the enemy. Keep down the weeds, as recommended at page 364.

Mice and snails little trouble wooden hives, but the uncleanly, ubiquitous earwigs are a nuisance. They are nocturnal vegetable feeders, and make, if they can, the dry, snug crannies about our hives their day quarters, which they sully with their droppings. They may be thinned considerably by providing hospitality. Put two pieces of unplaned board over the chaff-tray, or carpet, shutting between the two, plum skins, apple peeling, crushed cherry, &c., and keep the boards slightly separate by a stud of some sort. Open the trap, in the daytime, in a chicken run. They are destructive in the garden, seeming to prefer nibbling the petals of the most beautiful flowers, so it is a double service to trap them.

Wasps, of which we have several species, divided into the social and the solitary, are useful creatures in thinning off insect pests; but the social wasps annoy bees considerably, though they accomplish little

against strong stocks; the weak they often succeed in impoverishing. Destroy all queen wasps in the spring, as each of these—known by her large abdomen—starts an independent colony. Treat all nests of *Vespa vulgaris*, which are built in the ground, to destruction by turpentine, paraffin, gas-tar, or gunpowder. This is the more important, as large numbers hybernate in these nests.

Ants are rather tantalisers than enemies; populous hives prevent them entering. In wet seasons I have known them utilise bees in a most interesting manner, by spreading their larvæ (ignorantly called "ants' eggs") in a layer over and between the top coverings of the bees, so that the warmth of the latter and the dryness of the situation might duly bring the chrysalids to perfection. These were moved about, and carried up and down from the nest beneath, as circumstances dictated.

In closing this chapter, I cannot forbear asking my readers to consult any of the older writers on the subject. They will then, perhaps, be surprised to find that, in former times, birds, wasps, moths, mice, snails, and spiders, were the most dreaded foes, and diseases accounted as trifling and infrequent ills. How different the case now! Our modern hives keep the old pests pretty much at bay, but infectious disorders are on the increase, and *are also appearing in new forms.* It is no safeguard to shut one's eyes to a danger. Safety rather lies in a knowledge of the magnitude of any evil, and respecting this one, slackness is all but criminal.

CHAPTER XII.

THE CHEMISTRY OF THE HIVE.

Honey: its Constitution—Polarisation Defined: its Application to Detection of Adulterants—Corn Syrup—Dextrose—Cane Sugar—Microscopic Examination—Formic Acid in Honey: its Food Value—Wax: its Constitution; contains no Glycerine; Attacked by Lime—Melting Combs—Old Combs: to Treat—Gerster's and Jones' Extractors—Solar Extractor—Adulterants: to Test—Pollen—Propolis: How Used by Bees; How to Clean from Hands; to Prevent Adhesion of; Sources of; How Gathered by Bees; Useless to Bees under Domestication.

HONEY, although of varied hues and distinctive flavours, is still of fairly constant composition, its main constituents being two kinds of sugar, called dextrose and levulose, combined with water, which is subject to considerable fluctuation in amount, the average being between one-fifth and one-sixth of the whole; beyond these, small quantities of acid and some aromatic principles are present; while pollen is always found as an accidental addition. The blossoms whence the

bees gather nectar yield mostly *cane* sugar,* but this undergoes inversion through the action of the salivary secretion of the bee (see page 377 *et seq.*), and the two forms of glucose before mentioned are produced. The names dextrose and levulose imply right-hand and left-hand sugar, and need some explanation, since the properties to which they refer are the chief aids in detecting adulteration in honey, a question in which every bee-keeper has the deepest interest. To the mere chemist these two forms of sugar are identical, the composition of each being: carbon, 6 atoms; hydrogen, 12 atoms; oxygen, 6 atoms. Some difference, however, exists in the arrangement of these atoms, since the first is easily crystallisable, is not especially sweet, and turns the plane of polarisation to the right; the second is non-crystallisable, is very sweet, and turns the plane of polarisation to the left.

The whole question of polarisation is complex, but still a sufficiently clear idea of the involved point can be conveyed in a popular manner. Ordinary light is regarded as consisting of waves, or vibrations, travelling with inconceivable velocity, the various waves making up a beam moving in every possible plane.

* It has been calculated that one fuchsia blossom yields ·117 grains of sugar, five-sixths of which are cane sugar; one Claytonia, ·006 grains, two-thirds of which are cane sugar; each flower of the garden pea, ·153 grains, almost wholly consisting of one or both of the glucoses; vetch, ·002 grains per flower; red clover, the same amount. Accepting this $\frac{1}{500}$ grain per blossom as accurate, 3,500,000 visits must be paid to gather 1lb. of sugar. But all must know that the amount of honey in any blossom depends much on external conditions, and is liable to very considerable variation; while the supposition that clover only yields one seventy-seventh of that furnished by the garden pea (see page 306, Vol. I.), would appear to need verification, and I, after careful attention to the point, venture to think it very wide of the truth.

When the light is polarised, all its waves are in one plane. To bring this before the eye, let us suppose the bent wire *ab*, Fig. 125, to represent a simple wave, the plane of which is perpendicular—*i.e.*, the oscillations are up and down; then the wave, *cd*, making its oscillations sideways, would be said to move in a horizontal plane. Any number of such wires, put at random side by side, would represent an ordinary beam, the vibrations of which are in every plane, but if the wires all had their planes parallel,

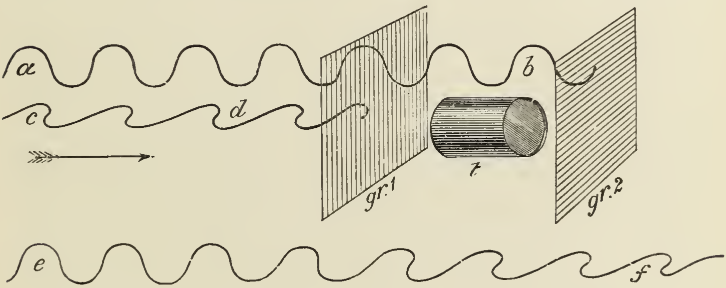


FIG. 125.—DIAGRAM EXPLAINING SUGAR ANALYSIS BY POLARISED LIGHT.

ab, Ray with Perpendicular Plane of Vibration; *cd*, Ray with Horizontal Plane; *ef*, Ray with its Plane undergoing Rotation; *t*, Tube containing Sugar to be analysed; *gr* 1 and *gr* 2, Gratings.

they would represent a beam of polarised light. Let *gr* 1 be a grating of perpendicular wires, set wide enough to pass *ab* or *cd*, if straight; then it is clear that *ab*, although bent, would still pass, while *cd* would be stopped. Many crystals arranged as prisms are optically such gratings; they will only allow rays to pass in one plane. Common light in going through them is therefore polarised. If a second grating, *gr* 2, be placed behind the first, with its wires horizontal, *ab*

is stopped, and every wire that can pass the first grating is stopped by the second; and similarly referring this to light, two prisms placed with their planes crossed—*e.g.*, one perpendicular, and the other horizontal, will stop all light.

Let us imagine a tube (*t*, Fig. 125) containing levulose in solution, held in by flat glass plates, to be put between the two prisms; the plane of polarisation of the light will then be revolved, during its passage through the levulose, towards the left, as at *ef*. If there be sufficient levulose, and the tube (*t*) long enough, perpendicular waves may be made horizontal. The amount of rotation is ascertainable by noting the position the second prism must take to exactly counteract the effect of the rotation caused by the levulose. Dextrose gives the opposite result; but since equal quantities of the same description of sugar always produce the same number of degrees of rotation, these quantities can be determined by an examination by polarised light.

The main adulterant of honey is corn syrup,* produced in America in enormous quantities by the action of acids at high temperatures upon the starch of maize. The starch is not wholly converted; some of it remains in the form of dextrine, a kind of gum, but the bulk is transformed into dextrose. Honey so adulterated would rotate the plane of polarisation to the right, whereas the opposite tendencies of the equal quantities of dextrose and levulose in pure honey would leave the plane of polarisation little affected, although, as levulose has more rotatory power than

* "Adulteration of Honey," Otto Hehner, page 12.

dextrose, the balance lies with the former, and a slight rotation to the left occurs.

The reader will have observed that dextrose is described as easily crystallisable, and yet it is used as an adulterant, not only to reduce the cost of production, but to *prevent* crystallisation, or candying of the honey (page 487). This enigma is explained if it be remembered that the corn syrup contains about one-fifth or one-sixth of gum (dextrine), which cannot be converted into sugar by the processes employed, and this gum is the actual preventive of candying. If pure dextrose were added, the honey would candy still *more* quickly as a consequence. The admixture of dextrine becomes evident if the material be fermented, when the gum remains, although the sugars disappear. The process of fermentation is brought about by the addition of yeast, and requires the presence of small quantities of nitrogenous material. Similarly, our forefathers were in the habit of converting their doubtful residues, after squeezing or straining, into mead * or metheglin—liquors of which I have no experience. The sugars are changed, under the action of the ferment, into carbonic acid, which escapes, and alcohol, which remains behind.

Cane sugar in solution is only rarely used to augment the volume of honey, its much larger cost not making it so suitable to the purposes of the adulterator as corn syrup. Cane sugar is, however, also easily detected by the polariscope, as it, too, turns

* Honey, diluted with about four times its volume of water, and exposed to the heat of the sun, in an open vessel, from which insects are excluded, will, in about six weeks, become strong vinegar. This vinegar has a very fine flavour.

the plane powerfully to the right. It is further detected by the copper test, over which it has no influence: while the sugars of diluted honey, if boiled with solution of sulphate of copper* made alkaline, reduce the copper salt to cuprous oxide, each molecule of sugar reducing five of copper, so that the exact amount of dextrose and levulose present in any volume of honey can be ascertained; at the same time, the amount of cane sugar, if any, may be determined.

If cane sugar be inverted (see page 378), by treatment with acids, *e.g.*, sulphuric or tartaric, and then used as an adulterant, the resulting mixed dextrose and levulose, being identical with the sugars of honey, cannot be detected by polarisation. Their origin, however, betrays itself by the traces of acid which remain, and which give white, cloudy precipitates with barium or lead solutions.

Sugar solutions of any kind, and however flavoured, if given in substitution of honey, are immediately detected by the microscope, as the counterfeit contains no pollen (see Fig. 127). Dilute the suspected material with about five times its weight of water, and stand twelve hours in a conical glass, when the heavier pollen will subside. Draw up the sediment by a pipette, or pour off the supernatant liquor, and examine with a low power. The amount of pollen discoverable in genuine honey is, however, extremely variable, depending not only upon the special bees which acted as collectors, but upon the flora and the character of weather at the time of gathering,

* This is used in the form of "Fehling's solution," for which consult any recent work on practical chemistry.

much wind often rendering the honey cloudy from the excessive quantity of pollen it then contains. If the specimen be only diluted with the syrup, pollen in small amount will be found, and the microscope is then incompetent to pronounce upon the fraud.

That the chemist and microscopist are able to expose so completely the miserable dishonesty which, to gain an unfair advantage, would strive to pass off a sophistication as a genuine article is highly satisfactory; but it is even more consoling to note that adulteration is on the wane—the first fact, undoubtedly, being the main cause of the second—and Mr. Otto Hehner has, by the able attention he has given to this subject, earned the good wishes of all honey-producers.

The acid quality of honey has already more than once been referred to. The contained acid is certainly partially formic, but in what association the chemist is not at present able fully to determine. Herr K. Müllenhoff* and the Rev. Wm. F. Clarke have pointed out that formic acid is provided by the bees by depositing droplets from their stings, which they touch on the face of the honey; Herr K. Müllenhoff adding that thus the presence of formic acid, absent in nectar, is accounted for. The acid, doubtless, exerts an antiseptic influence, and without it fermentation is likely. The expediency of removing honey while yet unsealed, and so economising the time and energy of the bees, is suggested, as the crop could be readily and cheaply preserved by the addition of $\frac{1}{10}$ per cent. formic acid.

The poetical conceits of the ancients touching honey

* "Archiv für Anatomie Physiologie," 1886, pp. 382-6.

are for ever dissipated, for not again can it be considered, except in a general sense, as ("*aerii mellis cœlestia dona*," Virg.) Heaven's gift; while modern science smiles at ("*quædam siderum saliva*," Pliny) the saliva of the stars. It is well that it should take its true place, as a delicious and most wholesome food, occupying, in the right of its own intrinsic merits, a position in our diet table from which it cannot be driven without loss.

Honey derives considerable character from the sources whence it comes; but it must be remembered that the special aroma and flavour of high-class honeys depend upon, relatively, very small differences, always supposing that the compared samples are properly ripened, have a high specific gravity, and are absolutely free of all uncleanly contaminations. Its food value depends upon its sugars, which are in the very best form for assimilation, since they are already* in the condition in which they are normally absorbed into the blood. They should, on this account, be taken in combination with some solid food, to retard their absorption, or the liver may have more presented to it than it can immediately deal with. Honey, masticated with bread, *e.g.*, is liberated in the stomach gradually, as the masses get broken up by solution of the gluten. It may thus well replace butter, while it is superior to sugar in many descriptions of cake and confectionery. The Rev. J. V. Moyle has devoted much time to multiplying the uses to which honey may be put, and the ingenuity displayed in this direction is surprising.

* "Honey as Food." Frank R. Cheshire.

Wax, as a secretion of special glands, with its circuitous derivation from saccharine substances in the body of the bee, and many other related matters, have already received attention in Volume I.; but we have yet to consider its chemical constitution, the substances used as adulterants, and the method of obtaining it in pure form.

Mr. Hehner has recently independently investigated the composition of wax, and has corrected the errors of his predecessors. If wax be boiled in alcohol, cerotic * acid, forming about 14½ per cent. of the mass, dissolves out, while the residue—myricine—remains practically unaffected. Cerotic acid crystallises in delicate needles, fusing at 172° Fahrenheit, while myricine is greyish-white, without crystalline texture, and fuses at 127°. If myricine or myricylic palmitate be boiled with an alkali, it is broken into two bodies—myricylic alcohol and palmitic acid, the latter uniting with the alkali, and forming a soap. Wax differs from fat, in that it contains no glycerine. The fatty acids, united with alkalis, always liberate glycerine, in soap-making, *e.g.*; but if wax be saponified, no glycerine presents itself, and thus the chemist is furnished with a method of detecting a certain class of adulterations.

Much wax is wasted through failing to note that lime in water unites with the cerotic acid, forming an insoluble lime soap; so that perfectly pure wax, if boiled over hard water, has, after cooling, a curious mass of material, greyish in colour and spongy in texture, lying under it. Wax should never be melted, nor should combs be rendered in any but rain or

* "The Chemistry of the Hive." Otto Hehner.

distilled water, unless to the water is added an acid, which, by uniting with the lime, prevents it from attacking the cerotic acid of the wax. Vinegar will do, but sulphuric, hydrochloric, or nitric acids, in small amount, would be better; a teaspoonful of sulphuric acid would be sufficient for half-a-gallon of water.

There are many methods of melting up combs so as to secure their wax; but if these be old, it is very essential that they be first most thoroughly soaked. It is sometimes stated that old combs yield no wax. The reason in part lies in defective treatment, though, of course, they never so well repay "rendering" as do the fresher ones. Larval excrement collects in quantity in old comb, and, if this be dry, no sooner is the wax set running, than it is soaked up in such a manner that it cannot afterwards be separated. When a sufficiently large collection of scraps and pieces of comb has been made to warrant a cooking, it is wise to sort over the whole, and start operations with the pieces in which breeding has not occurred. These, in the absence of any appliance, need only to be brought to the boil over a good quantity of slightly acidulated water, and then stood by to cool as slowly as possible, so as to permit the heavier dirt to sink to the lower surface. Next day the cake can be lifted, and the lower part scraped off. The removed *débris* may go into the second boiling, for which the combs should have been soaking from the previous day. The cocoon skins, thoroughly wet, will refuse contact with the wax, and the excrementitious matter also will remain beneath, staining the water a deep brown. After cooling, the exceedingly dirty mass,

now in comparatively small compass, should be placed in a canvas bag, along with a weight, and once more boiled with water, when it will yield almost all its wax if it be kneaded with a stick; and this, left to slowly cool as before, will be scarcely inferior in quality to that first obtained. Mr. J. M. Hooker recommends that the combs be put into a copper, and pressed down as closely as possible. A hoop, just fitting the copper within, is covered with cheese-cloth, and is pressed down over the combs, and kept in place by sticks wedged against the ceiling, or other means. The copper is now filled with water, and, upon boiling, the wax will separate from the refuse, and, rising through the cheese-cloth, can be taken off, when cold, in a solid block.

If tinned vessels are used for the melting, nitric acid must not be employed. Metal is undesirable with any acid, so that an excessive quantity should not be added; and if rain water be at command, it may be omitted. An iron vessel, made hot, and rubbed with any kind of fat, will not afterwards discolour the wax, as it is likely to do if this precaution be not taken; nor will acids in moderate amount now affect it. Copper vessels are to be preferred.

Those who desire a special appliance, will find the wax-extractor of Professor Gerster both convenient and effective. It fits, like an ordinary culinary steamer, over a large saucepan, and consists of a tin cylinder, within which is placed the perforated basket carrying the combs. Beneath is a circular tray, which receives the dripping wax, to be carried off by a spout passing through the side of the cylinder. The

arrangement has been improved by Mr. D. A. Jones and others, as seen in Fig. 126.

Having filled the comb-basket (A), returned it to its position in the extractor (B), and covered carefully by the lid (*l*), place the whole arrangement upon the stove, first, however, filling the bottom with water. The filler (*f*) gives a view of the amount during the whole operation, avoiding the risk of boiling dry, and also permitting the replenishment of

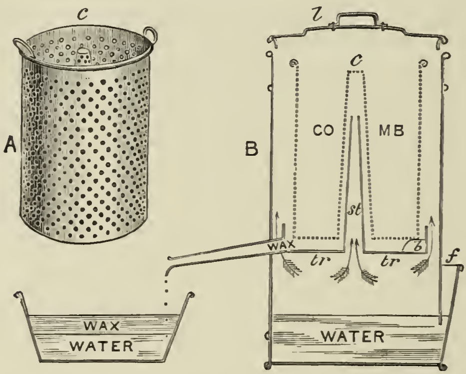


FIG. 126.—WAX-EXTRACTOR.

A, Perforated Comb-basket—*c*, Central Cone. B, Section of Extractor—*l*, Lid; *c*, Cone; *tr*, *tr*, Tray; *b*, Block to support Comb-basket; *st*, Steam-tube; *f*, Filler.

the tank without lifting out the comb-basket. Through the perforated metal walls of the latter the steam passes, gaining access to the combs, as indicated by the arrows both around the tray (*tr*) and through the steam-tube (*st*), wetting and heating the mass centrally and on the sides. The melted wax, dripping into the tray, is carried off by the spout to a vessel placed to receive it, which should have taper sides, so that

wax, when solidified, may be easily removed. These should be also slightly oiled, to prevent adhesion. The receiver should be placed on a cooler part of the stove, or be in some way gently heated during the process, while hot water, 2in. or 3in. deep, should be placed within it at starting; by this means the wax will be kept fluid, and the impurities will settle to the bottom of it, from which they may be sliced off when it has thoroughly set. These appliances save labour, and are very cleanly, altogether preventing the danger of boiling over, so likely to occur where combs are placed *in* water, as the molten, swimming wax in this case impedes the escape of the steam.

Wax may also be obtained by the solar extractor, which depends for its action upon the curious fact that glass is diathermanous for heat from luminous rays, and athermanous for obscure rays—*i.e.*, heat direct from the sun passes through glass easily, but by contact with material substances it is changed into obscure, or non-luminous, heat, which, as such, cannot re-traverse the glass. The accumulated temperature of green-houses, if exposed to direct sunlight, is thus accounted for, the heat passing into the house, but being unable to pass out again. The solar extractor is of most simple structure, and is, practically, a box having a sheet, or two or more sheets, of glass, one within the other, for its lid. Beneath comes the perforated bed, on which rest the combs. The wax drops through the perforations, and must be duly received below. It is sometimes mounted on a leg-stand with a universal joint, so that the glass may be presented to the sun wherever he may be situated. As it works dry, it

is of little service for old combs, and, in our uncertain climate, it might be quite unavailable when most required.

Perfectly clean wax having been obtained, repeating the process of melting over water, if necessary, it may be cast in moulds, which should be very sparingly oiled, or receive a trace of glycerine, to prevent adhesion. The cooling should be slow, or the mass will crack in shrinking, because the outside sets hard while the inner part is still hot. By slow cooling, the temperature throughout is nearly uniform, and the outside and inside contract together.

Many substances of animal and vegetable origin possess some of the qualities of, and bear some resemblance to, beeswax, and these, unfortunately, too often and too successfully, are used as adulterants. Mr. Raitt, as a practical judge, probably stands second to none, and on this matter he thus speaks:* "We have before us samples of 'beeswax' (?) of every shade of colour to be desired, of every degree of hardness, and tempered to any ordinary melting-point, but that never had any connection whatever with bees. Their basis is ceresin; they are softened by paraffin and stearin, hardened by Japan wax or Carnauba, their melting point raised or lowered accordingly, and tinted to perfection. They are then everywhere sold as 'pure beeswax'!!" "The various adulterants used, according to that which is wanted, are the mineral waxes, ceresin and paraffin, the vegetable Japan wax, myrtle wax of the States, and Carnauba wax of Brazil, the wax obtained largely

* *Bee-keeper's Record*, November, 1885.

in China from the insect *Coccus sinensis*, and such substances as stearin." The most serious disadvantage of these adulterants is that the doctored wax, although its actual melting-point may be preserved, loses tenacity when a high temperature is reached, and so combs built out from foundation made of it are liable, in summer weather, to drop from their attachments, and convert the previous beautiful order into chaos. Only last summer I saw most painful loss and annoyance caused in this way.

To judge of the purity of wax by ready methods requires much experience, but the following hints may be of service: Pure beeswax, unbleached, is of yellow colour, has an agreeable, somewhat aromatic odour, and a slight, but characteristic, taste. In the warm hand it becomes plastic, and, without either oiling or heavily coating the skin, is, under pressure, decidedly adhesive, while separated parts weld together very perfectly. Broken, at ordinary temperatures, it has a granular fracture, with a dry-looking, unpolished face; but when cut shows a glossy, waxy lustre, and when chewed does not stick to the teeth, but crumbles and breaks to pieces in the mouth, while a small percentage of adulteration will cause it to clog. Experts depend much on this last indication. Rosin is sometimes used as an adulterant, with the effect of making the fracture smooth and shining. The rosin can be slowly dissolved out in cold alcohol, while the wax remains untouched. By evaporating the alcohol, the rosin is obtained in a separated condition, and its amount may be estimated. Benzine, unlike alcohol, dissolves wax most readily, and so reveals at once

earthy matters, meal, or other insoluble impurities, added, not infrequently, to foreign samples, to increase weight. Benzine, as a wax solvent, is the best material for removing the latter from any fabric which may by accident have been sullied by it. Fresh wax melts at about 144°, but the melting-point rises 2° or so by a few months' keeping. The specific gravity of wax is nearly equal to that of water, and ranges between ·960 and ·965, water being 1·000. When adulterated with hard fats, its specific gravity is reduced, and on this fact Mr. Hehner has suggested an exceedingly simple test. Take a piece of undoubted pure beeswax, and cautiously mix alcohol (methylated spirit) with water until the wax just sinks ; a piece of wax so adulterated would, in the same test fluid, rise to the surface. The test must be applied, however, with great care, as any air-bubbles in or on the piece to be tried might lead to its being condemned unjustly.

Bees varnish their combs with propolis on the edges of the cells, where they often apply it quite thickly, while they add a thinner coat on the cell walls ; but it does not appear that this varnishing wholly causes the colour the wax possesses in bulk. The wax scales, as secreted (page 156, Vol. I.), are daintily white, but the combs may be, under special conditions, which are little understood, yellow at the very bases of the cells from the beginning.

Wax can be bleached by exposing it to the action of the ozone in dew ; but different specimens of wax behave differently under identical treatment. The usual plan is to run it out into films by dropping it upon revolving wooden cylinders half immersed in

water, and then, whilst screening from the action of direct sunlight, lest melting occur, exposing the films, upon canvas, to the action of the air—ozone being, as I have just stated, the bleaching agent. Wax may also be chemically bleached by the action of chlorine, or, indirectly, by nitric acid, as follows: To 1lb. of melted beeswax, add 2oz. of pulverised nitrate of soda; then stir in, by degrees, 1oz. of sulphuric acid, diluted in 8oz. of water. After partial cooling, boiling water is poured in, to remove the newly-formed sulphate of soda and the remaining acids. The wax is now white and translucent, less unctuous than before, and without taste or smell. Bleached wax is harder than the unbleached, its melting-point being raised, by the processes through which it passes, from 6° to 8°. On this account it is little fit for apiary work, and so has here no particular interest.

Pollen has received, in Vol. I., detailed attention, both in its relation to plant-fertilisation—to effect which the bee is so frequently the agent—and in relation to the food of the larvæ. It is gathered by bees, most generally, simultaneously with honey, and, although usually carried back to the pollen-basket of the third pair of legs, when on the wing, it may be duly stored without flying, as I have often noticed when bees gather from some composite flowers, such as single dahlias. That bees have this power, may be interestingly proved by making a paper case, or packet, about ½in. or ¾in. deep, and open at one end. If pea or lentil flour be placed in this, the bees will, when taking artificial pollen, enter in numbers, and, while *within*, will pack up the farina into large

pellets, beautifully smooth and regular, which, if pea flour be used, will resemble completely, in form and colour, the cotyledon of the pea—*i.e.*, the half seed after the skin has been removed. The shallowness of the case of course precludes the idea of the bees rising in flight.

Pollen is used in large amount during the breeding season, one stock often carrying, probably, 40lb. or 50lb. in a single summer. This is packed in worker-cells, with but few exceptions.

Some plants, such as *Nepeta Cataria* (catmint) and *Erica* (heather), so place the pollen on the bees' body (see page 292, Vol. I.) that it is not, as is usual, carried to the baskets, so that pollen cannot be said to be stored from these ; yet grains from their anthers constantly get mingled, in an accidental manner, with the honey, and may in it be detected. Pollen grains are beautiful objects, and some, having typical forms, or a special interest to bee-keepers, are represented in due proportion (except *a*, which is only magnified half as much as the others) at Fig. 127. The external envelope consists of cellulose, and does not digest, but becomes a bowel residue in the larva. From this it follows that not only will the honey, if microscopically examined, reveal the flora from which it was obtained, but the dark material collecting in old comb, if properly treated, will show the sources of the pollen upon which the larvæ hatched in the comb have been fed. The grains are all characteristically marked, and are very generally about $\frac{1}{1000}$in. in diameter; some are as much as $\frac{1}{180}$in., as in the vegetable marrow; others are as

small as $\frac{1}{3000}$ in., as in the forget-me-not and some poppies. The most commonly recurring form is a globe or egg-shape, covered with upstanding, blunt spines; that from the evening primrose (*a*) is large, the grains being held together by abundant filaments; those from the pea tribe are oblong (*e*); those from many of the thistles (*m*) sub-stellate; and from the clovers (*n*) fusiform, dotted and marked with a longitudinal groove. Thus, the bee-keeper may, if

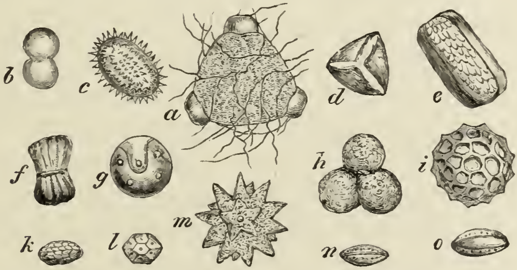


FIG. 127.—POLLEN GRAINS, VARIOUS.

a, *Œnothera* (Evening Primrose), Magnified 120 diameters; *b*, *Symphytum officinale* (Comfrey), Magnified 240 diameters; *c*, *Helianthus* (Sunflower); *d*, *Ajuga reptans* (Common Bugle); *e*, *Lathyrus pratensis* (Meadow Vetchling); *f*, *Polygala vulgaris* (Common Milkwort); *g*, *Ribes rubrum* (Red Currant); *h*, *Centaurea scabiosa* (Greater Knapweed); *i*, *Phlox Drummondi*; *k*, *Fragaria vesca* (Wood Strawberry); *l*, *Clematis Jackmanni*; *m*, *Carduus arvensis* (Creeping Plume Thistle); *n*, *Trifolium repens* (White Clover); *o*, *Cheiranthus Cheiri* (Wallflower).

armed with a medium microscope, detect whence his honey is coming. If possible, he should, however, before determining, carefully compare the material of the pellets, as gathered, with that from the plant he imagines to be the source of supply.

Propolis, a resinous substance, exceedingly tenacious, varying much in colour, but usually a rich brown, and which emits a balsamic odour, is used by the bees both as a cement and as a varnish. With it they

fill every crack the bottom of which they cannot reach; so that our movable frames, should they present much contact surface, are made fixtures, and the ventilating (?) straw skep becomes so impervious that, if inverted, it may hold water like a bucket.

New combs, as previously pointed out, are varnished by it, on the edges of the cell walls, which thus gain additional strength; and by its aid excessive ventilation may be reduced, or large, unwelcome openings may be closed. The doors of skeps are, not infrequently, veritably curtained by a thin plate of propolis, to which a varying proportion of wax is added; the curtains are carried downwards until the bees' notion of security and comfort is met. Some years since, leaving, by an accident, three or four frames of a hive quite exposed above, the bees commenced building out propolis, stiffened by wax, from the opposite edges of the top bars, until, by the time the error was noticed, they had very nearly finished a sufficient roof for themselves. From this practice of bees, in using propolis in their defence or protection, its name has been given, from the Greek *πρόπολις*, "before the city."

Propolis is collected in largest amount towards the close of the season, as though in preparation for winter; and it now becomes a serious nuisance to the bee-keeper, often sticking his fingers together, and staining them a greenish-yellow. Soap is almost powerless to remove it, but hot water and an alkali—such as soda or potash—succeed better, especially if the hands be first rubbed with oil or lard; but the best plan is, before the hands are

wetted, to apply methylated spirits (alcohol), which dissolves the propolis quickly, although it is not quite efficient in removing the stain. The structure of the hives should be such as to reduce propolising to a minimum, as in my anti-propolising frame (page 69), the comfort of using which can hardly be imagined by those having only ordinary types. The hands of the amateur will be considerably saved by moistening with glycerine before and during manipulating, as the glycerine intervenes between the skin and the propolis, and prevents adhesion. Great comfort will also be secured by carefully rubbing tallow—or, better, vaseline—upon the parts which it is desired to move, as the bees are disinclined to propolise greasy surfaces, while the grease keeps the propolis in such a soft state that it does not accomplish the purpose intended by the little artificers. Some races propolise less than others, notably the Carniolans; while none gather any after October, until the succeeding April, so that clean fixings put on in wintering will so remain until the following spring.

The sources of propolis are many, the leaf-buds of various shrubs and trees providing it—the poplar, the alder, the beech, the willow, the fir, and others, giving resinous exudations in the axils of their leaves and bracts; while, *e.g.*, the resinous and exceedingly adhesive leaf-buds of the horse chestnut, and the varnish-coated blossom-buds of the hollyhock, must be known to all. Huber, in his experiments, planted some branches of the wild poplar before the leaves were developed, and placed them in pots near his apiary. The bees, alighting on them, separated the folds of the largest

buds, extracted the varnish in threads, and loaded with it, first one thigh, and then the other; for they convey it like pollen (page 131, Vol. I.), transferring it by the first pair of legs to the second, by which it is lodged in the hollow of the third. Bees are not only exceedingly clever in finding natural sources of supply, but they freely adopt artificial ones, pressing into their service resinous gums, varnishes, and even pitch. They also value propolis as a second-hand article, and will scrape it from old, disused hives and coated quilts, making such, in case of disease, a fruitful source of trouble. Bees in some localities—those devoid of trees—carry scarcely any propolis. In one such case in my knowledge, sunflowers were made to yield a substitute, in the transparent, adhesive exudation they furnish.

If a piece of propolis be placed on the finger, and a seat be taken near a hive, ere long a bee will be at work appropriating the treasure; and in this way I have studied, with a hand magnifier, their methods of packing it. The mandibles, by a gnawing process, cut off a ribbon, which passes down under the thorax. This, by a process of mastication, is softened, and carried by the legs, backwards, without soiling any part of the body, and finds its way to the pollen (?) basket, where it glistens like a tiny, brown, glass bead. The bee, loaded, returns to the hive, and here the expectant painters lay hold of the material with their mandibles, pull it off in strings, and apply it as desired; for it is never packed in cells, but put into position at once, the propolis-carrier thus not unloading herself, as in the case of pollen. Propolis, in

all proportions, is miscible with wax by the bees, and they employ the two in blend, as occasion may require.

Little propolis is gathered while the bees are busy over a good honey yield, but when this closes, painting begins in earnest, and, if section-boxes are left on too long, they may be made very unsightly by every inequality in the box itself getting a little patch of brown stopping, while the capping of the comb may be thinly glazed, so as to considerably damage its appearance.

Propolis is not necessary to bees under domestication, although its value to those in a wild state, in securing needed comfort and safety, is apparent. The disposition to propolise is, no doubt, capable of considerable reduction by careful selection, as the amount carried by various stocks, apart from the question of race, is very unequal. At a period when bitumen from a mummy was regarded as invaluable in the healing art, because oddity in the source of any material was supposed to confer upon it strong curative qualities, propolis, as might be imagined, was found upon the shelf of the apothecary, whence, however, it has now disappeared. Once it was used in varnish; but even here its fancied virtues have fled, for modern light has shown it to be only resinous matter, of unequal character, and continually associated with every description of dirt. Neither art nor science now will have it, and the bee-keeper only wishes that the bee could be taught that collecting it is worse than labour in vain.

CHAPTER XIII.

RACES.

Necessary Qualities of Bees for Profit—Crosses—Fertilisation in Confinement: Experiments upon—The Genus Apis: its Natural and Artificial Distribution—Species Mellifica: Characteristics of—Species Ligustica: Colour Bands of; Characteristics of—Cyprians: their Introduction; Characteristics of; Temper of—Carniolan, or Hungarian Bees—Crosses Naturally Breed Out Drone Element—Ligurianising—Albino Bees—Species Fasciata, Adansonii, Unicolor, Caffra, Scutellata, Nigritarum, Indica, The Bhootan Bee, Dorsata, Florea—Stingless Bees.

THE species and varieties of the hive bee, with their geographical distribution, would require a volume for their complete treatment; here, therefore, we must be content with such a summary as may guide the bee-keeper in making a choice of stock, so that his capital and labour may yield him the best possible return. Bees with marked energy, unquenchable industry, and great powers of endurance, are evidently necessary if conspicuous success is to be achieved;

while, amidst a whole catalogue of minor qualities, the queen should be distinguished by fecundity; the workers should be, above all, notable honey-gatherers, and rapid builders of flat, highly-finished combs, in which drone-cells are not over numerous, they should winter without difficulty, and be of reasonably mild temper: and since the various races differ widely amongst themselves, bee-keepers are justly inquiring which race or races, and whether a cross or a pure bee, will be most likely to realise their ideal.

Testimony is pretty general in favour of crosses as working bees, and this should modify the disappointment all must feel in the relative failure, up to the present time, of controlled fertilisation. The miscarriage of artificial methods has already come before us, at page 323, and further efforts, during another season, have only made me feel the more strongly the accuracy of the opinion I there ventured to express. Artificially fertilised queens may be of great value in securing a pedigree stock, but they, I fear, will never be of service in heading colonies in actual work, since the number of eggs they are capable of fecundating, unless our methods much improve, will always be very restricted.

Fertilisation in confinement would appear to have been occasionally successful, with the most simple means, during the last ten years at least, unless we must suppose that testimony has been given under a total misapprehension. Yet it is evident that the hope of progressive apiarists has met disappointment in many experiments carefully and expensively undertaken. Mr. Simmins has, during two seasons, been

struggling with the problem, and although conquering difficulty after difficulty, and giving to his queens and drones considerable flight-space, he has failed, up to the present, to achieve what could be called a practical success. Mr. McLain* has had very similar experiences, as in his last Report he states that he had six colonies in a house 10ft. by 16ft., and 8ft. high, partly covered with wire-cloth. These colonies knew their location, and returned freely to their hives. Into these six virgin queens were introduced. When the latter were five days old, ten drones were liberated near to the entrance of each colony. Most of the drones persisted in flying against the wire. "When the young queens flew from the hive, seeking a mate, they mingled among the drones, crawling over them, and caressing them with their antennæ, meeting with no response. These queens, with one exception, seemed to have no difficulty in getting the location of their respective hives." The result was, one queen mated. Mr. McLain concludes that the difficulty was in the irresponsiveness of the drones. To explain this, he supposes drones not capable until specially fed by the workers, an idea for which I venture to think the evidence insufficient. He seems to believe this special feeding supplies the secretion which I pointed out as coming from the mucous gland (see page 199, Vol. I., where I have explained that drones are not all, or always, in a virile condition). Having inserted six other virgin queens into the same six stocks, he secured a strong colony under the swarming impulse, in which queen-

"Report on Experiments in Apiculture," by Nelson W. McLain, 1887.

cells were being built. This colony was placed in the house previously mentioned, the wings of the old queen being clipped. Drones were soon found in nearly every hive in the house, and three of the six queens were fecundated. Mr. McLain is hopeful, and intends trying in a larger, wire-covered inclosure, and concludes by saying: "If practical control of reproduction can be secured by so simple and inexpensive a method—and the facts, from my experience, as given above, seem to warrant the conclusion that this is true—then the Rubicon of scientific apiculture is passed;" an expression of opinion which appears to me to over-estimate the general importance of fertilisation in confinement, which never can be more than exceptionally applied, however practicable it may be made. The selection of the queen is always possible, and the extent of the influence this exerts must be judged in the light of previously-considered facts, and what is subsequently said respecting crosses.

The genus *Apis* contains about sixteen species, which have such a near approach to structural identity that some naturalists are willing to regard *mellifica*, our native bee, as the generic type, of which a few at least of the so-called species are merely varieties. It is urged by such, that *mellifica*, *ligustica*, and *fasciata*, *e.g.*, interbreed with avidity, and that their progeny are prolific; but this is no proof of specific oneness, as closely-allied but universally-admitted species often possess the powers indicated.

The whole genus is naturally restricted to the Old World, for although members of it have now become naturalised in America, Australia, and the islands of

the Pacific, they were originally conveyed thither by Europeans; and, respecting their introduction to North America, it has been remarked that the Red Indians were in the habit of noting the gradual absorption of their territory by the white man through the forward advance of his herald, *Apis mellifica*. This species has also been carried to India and Northern, Western, and Southern Africa.

The structural similarity obtaining among the different species greatly simplifies our present task, for all our past studies apply, with equal force, to nearly every member of the genus; and our work now lies in merely marking differences in colour, size, temper, and capability, together with such variations in habit as may make the several species more or less desirable for culture.

Apis mellifica, the brown or German bee, which is indigenous to middle and Northern Europe, and our only native, domesticated species, commonly referred to as the black bee, is of sombre hue, though its brownish-black body is relieved by definitely arranged hairs of lighter colour. It is well known to us all, and must, therefore, be our standard of comparison. The advent of the brighter-coloured Southern and Eastern bees has eclipsed *mellifica* perhaps more completely than was just. True, its temper, although not equally irritable in our different strains, is always uncertain, and it is far too fond of buzzing before the operator's nose in threatening style, even showing its general awkwardness to those who only venture near to its door. If long under manipulation, it gets into a ferment, and is prone to boil over the top of the

hive, while the bees on the fullest combs run into lumps, hide the queen, or tumble off pell mell in their hurry. Amidst its other faults, it is quarrelsome with neighbouring bees, yet only an indifferent defender against robbers; it unites badly, does not easily learn a new location, and is relatively slow in building into strength in spring; but it is a good honey-gatherer, and usually, in my experience, flies as early and as late as Italians. One good point it has, which should atone for many faults—it excels as a comb-builder, and places over its honey, cappings of snowy whiteness, beside which the work of the yellow races is patchy and inartistic; and the comb honey so sealed is less liable to injury by damp. This race is also less prone to swarm out, and leave unfinished sections. It is not its habit to clog the brood-nest, and, as a possible consequence, it adopts sections more easily than the yellow races. Here, then, are good and bad qualities associated. The object of the bee-keeper would be achieved if judicious crossing could retain the comb-building capabilities of the native race, and yet secure the greater coolness and fecundity of the Italian. Many crosses of Italian mothers with black drones produce splendid honey-gatherers and good builders, while the queens are easily found because of their light colour; but the temper of the workers is often at fault. Judicious selection should each generation bring us nearer to the bee required.

Apis ligustica, the Ligurian, Italian, or Yellow Alp bee, although long known to naturalists, did not attract the attention of bee-keepers until nearly thirty years ago, when, in our own country, Germany, and America,

it quickly rose to high favour. M. Hermann, a bee-cultivator, Canton Grison, Switzerland, transmitted the first consignment of living Italians that reached our shores to Mr. A. Neighbour—the late Mr. Woodbury, the "Devonshire Bee-keeper," receiving, in the same package, a queen and her attendants. These arrived July 19th, 1859. Since that time, importation has been continued, and the race multiplied, until almost all our black bees give indications of an admixture of Italian blood.

The Italian Alp bee, called Ligurian, from Liguria, the Roman name for the district lying immediately North of the Gulf of Genoa, really extends over Northern Italy and South-eastern Switzerland, its limits being set by the Helvetic and Carnic Alps. There are, however, two types of the Italian. The smaller, very bright in its colouring, possessing a yellow scutellum, and a less amiable temper than its relative, is referred to by Morawitz and Douglas as suited to hot climates, and is stated by Dr. Gerstäcker to extend to the islands and mainland of Asia Minor and the Caucasus. This is mainly found in Southern Italy. The larger, rounder, more tawny, and better known type, commonly called the "leather-coloured Italian," prevails in the North; but these differences shade insensibly into one another. This bee is somewhat less than *mellifica*; the abdomen is flatter and more pointed, but the main distinctions lie in colour. The six telescopic, abdominal rings of *mellifica* are all dark, but four light bands cross the dorsal (back) plates, consisting of very closely-set, short, tawny hairs. When, by the presence of *Bacillus*

Gaytoni (page 569), these hairs drop, the colour of the plates is fully seen, and hence the name "black" bees is then given. These hairs are present in the Italian, and, as before, on the second, third, fourth, and fifth abdominal rings, but are lighter and yellower; while the first three rings are themselves in large part a transparent, tawny yellow—transparent, as may be seen by allowing a bee to fly on the window-pane. The first abdominal ring on the dorsal side mainly faces the thorax, and may be missed by careless observation; its lower edge only is black. The upper two-thirds of the second is yellow, the upper third smooth and hairless, because this passes beneath the ring above it when the body is contracted. A band of yellow hair covers the second third, and adds much to the beauty of the bee, as hairs and ground are alike yellow. The lower third of the ring is glossy black, carrying many microscopic hairs, and a minute fringe. The third ring resembles the second, while the fourth and fifth carry yellowish hairs, but are black. The sixth ring, black also, is nearly hairless.

These are the characteristics which mark off "three-banded Italians" from hybrids, which, amidst much variety, only in a few instances carry the three bands, although the second abdominal ring is usually well marked; but, amongst the first cross even, we find some that are only slightly removed from the pure black, showing touches of yellow near the ends of the first dorsal plate, though the drones, of course, retain the appearance of the pure Italian. Many *imported* Italians do not fully exhibit the yellow of the third abdominal ring, and so it has been pretty

generally conceded that the Ligurian is not a pure race. Be this as it may, it must be remembered that we have sufficient evidence that dark bees do exist in Italy, and that the Italian and German bees are in contact between the extremities of the two mountain ranges previously mentioned; and, indeed, I have seen several lots of imported "Italians" which, if bred in this country, would have been pronounced undoubted hybrids. The under side of the abdomen is parti-coloured, the plates being indefinite tawny yellow about their edges, and dark brown in the middle. Yellowish hairs cover the thorax and head, and, as here the skeleton is browner than in *mellifica*, the whole bee looks lighter and yellower.

The drones are smaller than are those of *mellifica*, and are not nearly so yellow above as the workers. On the under side of the abdomen, however, yellow preponderates, the last plate beneath being quite light. The queens vary greatly; some have the abdomen long, beautifully taper, and nearly wholly yellow. I have had them quite yellow, except a chocolate-brown dot in the median line, on each dorsal plate. Such queens are not only handsome, but are found most readily, even by those not quick-sighted in these matters. Others are so dark that they closely resemble the queens of *mellifica*. Nor is the variation limited to colour, some being so small that they hardly exceed workers in size. The legs of an Italian mother are a yellowish-brown.

This race is very generally of mild temper, calmly bearing manipulation, and is readily subdued by smoke or carbolic acid; it adheres steadily to the comb, when

this is lifted from the hive, the queen then still continuing to walk deliberately, often depositing eggs while under observation. The queens are very prolific, and can, under proper handling, fill an enormous brood-nest ; the bees, in consequence, rapidly build up in the spring, and can bear artificial swarming to an extent that would be ruinous to blacks. They are splendid defenders of their stores, but, upon little encouragement, become determined robbers. They are almost proof against the attack of the moth, and this has much to do with their reputation in America, where the moth is so destructive. As honey-gatherers they are most excellent, and, for industry, unsurpassed ; but under unskilful treatment they are likely to convert too much of that they gather to nursery uses, instead of gratefully hoarding for a kind, though inexperienced, master. Failing here, many have condemned Italians and other yellow bees, while want of knowledge in the apiarian himself has been the weak point. Their comb honey is not equal in appearance to that produced by blacks, but for extracted honey they are very profitable bees. They winter indifferently, unless carefully protected, not being so truly a mountain race as some have stated. There is little doubt but that their beauty and gentleness have been the main causes in making them all but universal favourites, and that their importation, by introducing new blood, has been a general advantage to our native *mellifica*.

A few years since, the announcement was made that another and superior race of bees had been discovered on the island of Cyprus, and that Chan-

cellor Corri had imported them into Europe. One or two queens arrived in England, the very first coming, from Mr. Jackson, into the hands of the Author; but they were useless as tests, because weak, and probably diseased, as they were unable to remain on their combs. Glowing descriptions, however, of the beauty and value of these bees, together with reports of another race in the Holy Land, aroused enthusiasm, which reached the far West, and Mr. D. A. Jones, of Canada, seconded by the able Frank Benton, set sail from New York on January 1st, 1880, on a voyage of more than 6000 miles, in search of the new races. On the return journey, Mr. Jones passed through London, and the Author, amongst others, then met the traveller, and saw his treasures. Cyprian bees could now be really tried. If the Italians are beautiful, the Cyprians are lovely: smaller, flatter, more taper, brighter in colour, the yellow being rather orange than tawny; the bands and pubescent hairs of the abdomen are similarly arranged, but both the black and yellow are more strongly marked than in the Italian. The back of the thorax is also yellower, and the scutellum (at the after part of the thorax, above) brightly yellow. The abdomen is quite bright at the sides and beneath. The drones—one-third smaller than those of *mellifica*—are beautifully coloured, yellow preponderating, and require to be seen in spirits to be fully appreciated. The queens—brighter in tone, and more uniform than the Italians—are lively, and of good size. Their breeding powers are immense, and they have a curious disposition to raise very large numbers of queen-cells, these sometimes reaching

fifty or more. The good and bad points of Italians seemed to be intensified in Cyprians, temper excepted, which was described by many as demoniacal. It is true that, when *thoroughly irritated*, they make war with a will, and the bee-master needs the philosophy of a stoic, or the hide of a rhinoceros, if he is to stand his ground, for the enemy will submit under no treatment that does not involve decimation; but, doubtless, the troubles—of which the Author has had to bear his part—following the introduction of these beautiful bees were largely due to want of special knowledge of the race. A better acquaintance with them shows that, with proper handling, they are amongst the gentlest of bees. Probably, very savage Cyprian stocks were once not uncommon, and, even yet, now and again occur (see page 23); but of such, in recent years, I have seen no example. It is not my practice to use a veil in manipulating them, and for slight operations no kind of taming appliance is provided. By opening the hive deliberately, and, if there be a little disposition to fuss, waiting just a few seconds, almost anything may be done, with only a remote chance of a sting. Indeed, I always feel safer with them than with Italians, and would select them or Carniolans, in preference to any other, for showing to an unveiled stranger. The manner in which they are cultivated in Cyprus seems to forbid the idea of ferocity, as the hives are often built into the walls of houses, which exist in narrow streets.

The fecundity of Cyprians is prodigious, and their honey-gathering powers great indeed. They build comb

rapidly, and, naturally, make few drone-sized cells. They winter better than Italians, and quickly grow strong in the spring. Mr. Benton claims that "where Italians or blacks could not survive, the Cyprians will live and flourish." He attributes their high quality to the unfavourable conditions surrounding them in their native island, where forage is often so scarce that it is wonderful that a bee remains. The untiring energy and perseverance necessary to maintain a subsistence under such circumstances, have developed their characteristic activity and restlessness, as well as fitted them for better defending their stores.

The Holy Land or Syrian bees are found on the higher ground of the Holy Land and Syria. Although they vary amongst themselves in minor characteristics, they are possibly the progenitors of the two previous yellow races. Mr. Silas Clark says of them: "They have existed thousands of years—evidently from the foundation of the world—and have had no chance to mix with other races. The monks in the old convent near Jerusalem believe that they were the first bees given to man." My acquaintance with them is restricted, but those I have seen are decidedly inferior in brightness to Cyprians, although their markings are similar and their bodies larger. They are splendid foragers, flying, if necessary, to great distances from their hives. Their tempers appear to be, unfortunately, liable to considerable fluctuation, although many stocks can be handled with the same ease as Italians.

When visiting the Rev. G. Raynor, I had given to me some most remarkable pieces of comb, proving

the curious habit of this bee in building extraordinary numbers of queen-cells. Each comb in the hive was surrounded—below and on the sides—by a double row of these cells; and each section-box was similarly furnished. The stock threw seven swarms; from the first, twenty-one queens were found killed, and ninety queens were found free in the hive, the cells showing that 170 queens had been raised. The Cyprians exhibit the same peculiarity, in a less degree. The Syrians also develop fertile workers, quite usually, during an interregnum; but the difficulty is less than with other races, since the fertile workers do not interfere with the raising or introduction of a queen, and when the latter begins to lay they subside.

In order to see the full beauty of Syrians or Cyprians, or, indeed, any yellow race, the comb must not be removed from the hive, for the wings then reflect the blue tints of the sky, and break up the yellow colour. Separate the combs widely, and look down between them.

Carniolan or Hungarian bees are universally recognised as extremely gentle; they do not seem to be specifically distinct from *mellifica*,* although the variation is well marked. The form is like to that of our native bee, yet somewhat larger, and more robust. Its hue is dark greyish-black, frequently showing two indefinite, orange spots near the extremity of the first dorsal plate of the abdomen. The most conspicuous distinctive feature, which gives it a quiet beauty, lies in the four rows of pubescent hair, which

* There are several varieties of *mellifica*, some being useless: heath bees, by example.

are denser and much lighter than in the ordinary bee. The queens are larger, and often of a pale bronze colour, while the drones are strong and solid (see page 212). The popularity of this bee has grown suddenly, but is fully justified by its excellent qualities. The merest novice can handle it in confidence. It is a grand comb-builder, making cells slightly larger than those of our native bee (page 211). It gathers very little propolis, using wax instead. It winters magnificently, coming in strength right through into the spring. With great force of constitution, it is long-lived, so that nuclei retain their numbers a lengthened period, in the absence of laying queens. It is very prolific and industrious, and gathers honey in large amount; but it is a free swarmer. This point can be dealt with by the intelligent apiarian.

The bees crossed between Cyprians and Carniolans, although unequal in colour, are yet beautiful, for where the yellow of the Cyprian is wanting, the dense, light pubescence of the Carniolan is present as a compensation. As a business bee, this cross promises, perhaps, better than any other.

Respecting crosses, it must be observed that there is a constant disposition to breed out the drone element. Suppose, *e.g.*, a large apiary to contain Carniolan mothers, suffered to produce no drones, the latter being entirely provided from one or two Cyprian colonies in which drone-breeding is encouraged. The swarmed colonies become hybrids; and, if the pure mothers are now replaced by similarly cross-mated queens, it may be supposed that the apiary has the chosen cross established in

it. Such is not the case: the following summer, all the drones produced in the hybrid stocks will be Carniolan, and, unless the supply of Cyprian blood be kept up, the stock will, collectively, gradually revert towards the Carniolan type (see page 321). This fact seems to have escaped the attention of those who wrongly assert that, unless we can absolutely control fertilisation, no advance can be made in the production of a special strain. It is clear that the queen exerts three times the influence over her posterity that the drone does, since her blood is one-half of that of the fecundated daughters, and the whole of that of the sons.

The circumstances just enumerated greatly favour any attempt at establishing one race in lieu of another; *e.g.*, in what is called "Ligurianising," one or two, or any number of Ligurian queens, are introduced into an apiary. They are encouraged in drone-breeding, and other drones are, as far as practicable, banished. Some queens are purely mated, some crossed. The crossed ones the second year raise the drones, which are still pure, and the purely-mated furnish the queen-cells; and in this way, theoretically, Ligurians may be made to supplant blacks, or any one race any other. Practically, unless a position of great isolation can be secured, it is not so, for bees seem to prefer crossing. Many years ago, when bees were few about me, I placed twenty pure queen-cells in as many stocks. I had abundance of Ligurian drones, and none of any other race—nineteen of the queens crossed; this has been cited as evidence of the difficulty of securing pure im-

pregnation, but I regard the case, myself, as an extreme one. Although the drone from the cross-mated mother is pure, it must not be forgotten that a drone from her daughter is crossed ; so that these daughters must neither be allowed to furnish drones nor provide queen-cells.

The practice of selection may soon bring into prominence any existent feature, and sometimes, with care, a sport may be perpetuated. Either selection, or a sport from the Ligurian, has produced the so-called Albino. I believe it to be a sport, because a similar instance occurred in Mr. Benton's apiary, in a queen, now in my possession. The term "albino" is quite incorrect, and should not have been applied. For an instance of true albinism, see page 117, Vol. I. The bees under consideration are whiter in the body than Ligurians, because the down is lighter; while the abdominal rings are somewhat paler in colour. Much difference of opinion has been expressed respecting these albinos : by some they are vigorously praised, by others as strongly denounced, as weak and profitless ; the mean probably nears the truth, as there seems no reason why they should be better or worse than other Ligurians, for such they undoubtedly are.

Having now considered those races that have secured a favourable report, and which seem to possess the points requisite for building up an ideal bee, or "the coming bee," as our American cousins are fond of saying, let us give a glance to the better known of the other species of the genus *Apis*.

The most important of these is *Apis fasciata*, or the Egyptian bee, found also in Arabia and Asia

Minor. The workers are rather smaller than the Italian. The general colour is a blackish-brown, with abundant whitish pubescence. The nervures of the wings are russet colour. The first two, and part of the third, rings of the abdomen are dark orange.

This bee was introduced into Germany, in 1864, by M. Vogel, and into England, in 1868, by Mr. Woodbury; but it seemed to the latter to possess no superiority, while he found it excessively vicious. *Apis fasciata* was domesticated in Egypt, in a remote antiquity, as is proved by reference* made to it in one of the earliest hieroglyphic writings that have come down to us, carrying us back to the period of the building of the Pyramids. The valley of the Nile is well isolated, and thus the purity of the race would be preserved; but it is quite supposable that a branch of it would push on north-east, and so develop into the Holy Land and Syrian bees, which may not be the originals, as Mr. S. Clarke supposes. Conjecture will serve no useful purpose, but some naturalists incline to this opinion.

The ancient Egyptians originated the idea of a floating apiary; the hives were placed on boats which ascended the Nile, as in its upper parts the annual inundation more quickly subsided, and was immediately succeeded by melliferous flowers. The boats descended the river so as to secure the most abundant pasturage, reaching Lower Egypt in the month of February.

* Sir Gardiner Wilkinson draws attention to a hive being represented upon an ancient tomb at Thebes. The ancient Egyptians were also acquainted, doubtless, with the economy of the bee in having *one* queen, as the figure of the bee was adopted as early as the Twelfth Dynasty, expressing, in symbol, the idea of a people governed by a sovereign.

The boats shifted their position during the night, so that bees might not be lost. Niebuhr states that he met upon the Nile, between Cairo and Damietta, 4000 hives. Mr. C. Perrine attempted a similar plan on the Mississippi in 1878, putting nearly 500 colonies into two barges, which were to be towed up the river, and so keep company with the great honey flow, as it gradually passed northwards, where, of course, the season is later. The great loss of bees, by dropping into the water, made the experiment so like a failure that the idea is now quite abandoned.

Apis fasciata crosses freely with the drones of the yellow races, although, among other distinctions, its cells are smaller, eleven across the parallel sides measuring 2in.

The species *adansonii* (Latreille) resembles *ligustica*, but is again smaller. It exists in Senegal.* The natives hang the hives in the branches of trees, to preserve from abounding lizards. The harvest, consisting of honey, used as sugar, and wax for exportation, is taken by stifling the bees, and emptying the hive, which is now restored to its old place, awaiting a swarm looking out for new quarters, and does not usually remain long uninhabited, since swarming continues nearly throughout the year.

Apis unicolor (Latreille), with a black, shining abdomen, without bands of colour, is cultivated in hives in Madagascar; but the honey is often unwholesome, being, in part, gathered from the abundant euphorbias. This bee has been taken to the Isle of Bourbon and Mauritius, and also to the Canary Islands.

* Maurice Girard, "Les Abeilles."

In the south of Africa, two species of *Apis* are found: *Apis caffra*, black, with the base of the second segment of the abdomen dull red; and *Apis scutellata*, with the abdomen brown, and the base of the segments clothed with ash-coloured hairs.

It is by no means clear what species of bee has been known amongst us as "South African," the only surviving specimens having been in the hands of Mr. Simmins, and, by his kindness, of myself (see page 346). The queen was probably hybrid, as the bees were differently marked, yet most jet black on the abdomen, with lines of white hairs; so that they did not agree with either of the foregoing, being probably in part *mellifica*. The South Africans, whatever they were in race, indicated that they were not likely to be an advantage in our climate. The queen bred vigorously, but the stock did not increase, for the simple reason that the young bees dispersed themselves in all directions, some hundreds being found sometimes in near-standing stocks; and, again, when the temperature is not quite high, they remain within, and gather nothing. Their disposition to throw fertile workers (page 355) into other colonies is a serious drawback, for the nuisance is frequently a fatal impediment to the raising of a queen from an inserted cell, and to the introduction of a virgin queen; while, in their presence, stocks are rapidly brought to ruin.

In equatorial Africa, in the Congo region, *Apis nigritarum* is found, with black antennæ, carried upon a yellow tubercle; black abdomen, grey down, with the first segment, and the base of the second, yellowish. the wings being transparent.

India has several species of hive bees, and the climate is exceedingly favourable to apiculture, yet the industry is, generally speaking, so ill-developed as to be only of slight commercial importance. A great field seems to be open for the application of scientific methods in the handling of native races, and so producing honey in large amounts, of good quality, free from pollen and brood-juices—an art in which the Hindoo needs European instruction. Wax could also be produced in vast quantity. It remains yet to be seen whether the Ligurian, Cyprian, or Syrian, may not, especially in their mastery over the wax moth, be superior to any native bee. Mr. J. C. Douglas, who has especially studied this question, is strongly in favour of the introduction of the southern variety of the Italian. The proper solution of the problem would be of advantage to our Indian Empire. But it must not be supposed that throughout this vast collection of countries the native plans are all equally primitive.

In Lower Bengal they have not progressed beyond the adoption of an earthen vessel for a hive, and the destruction of all the bees when taking the honey. In the Punjab they use cylindrical hives, made for the purpose to which they are devoted, and formed of wooden logs, or earth and wattle; and here the bees are more productive. In Cashmere, the hives are built, as they are further west, in the house walls, the bees and their brood-nests not being destroyed, as the honey, which is stored behind, is removed from within, whilst the bees are driven forwards by tapping and smoke. Here feeding on meal and sugar, or honey, is practised. The most advanced bee-keepers

are in the Bashahr district of the Punjab, where a variety of *Apis mellifica* is found, and special provision is made for the bees in the construction of the houses. These have roofs extended to form a wide verandah. The walls are of wooden bars, leaving square openings, into which earthenware hives are fitted. The door behind admits the swarm, and also permits of the removal of the harvest, the bees entering by a hole in front, beneath which is a small earthenware alighting-place. The men devote a considerable part of their time to the care and protection of the bees. There is interest in the observed fact that, where the same species of native bee is found, both in the hills and on the plains, the variety inhabiting the colder climate is the more productive.

Apis indica is very widespread, being not only common in Hindostan, but in the islands of the East Indian Archipelago, notably in Java. It is a small bee, black, with grey pubescence, with the first and second abdominal segments of a brown red; but the colour-bands are distinctly yellower on the lower grounds, or where temperature runs higher. It builds comb between ½in. and ¾in. in thickness, with six worker and five drone-cells to the linear inch. It has been successfully cultivated by a few Europeans, in frame hives, on the hills, and both super and extracted honey, its product, have been exhibited. It is kept by the native Hindoos in rude hives of various builds, but frequently made like a drainpipe, of bamboo, and shut at the end by board. These hives are often placed, by the natives, beneath the gutters of their houses, they

destroying the bees periodically. *Apis indica* is likely, especially in the wild state, to suffer badly from the moth, enormous numbers of wild colonies perishing every season from this cause and want of stores; for it is noticed that, in Lower Bengal, *Apis indica* collects very little, if any, surplus honey, but that the surplus is surprisingly increased by domestication, and bears no fixed relation to that which would be produced by the same bee naturally.

The Bhootan bee* is, probably, specifically distinct from *Apis indica*, than which it is a good deal larger. All the bees, including the queen, are very dark, with white hair. Their worker-comb has 5½ cells, drone-comb 4½ cells, to the inch. They are exceedingly mild in temper—so much so, that the guards retreat immediately, instead of offering a defence—and have been kept, experimentally, by Europeans, in frame hives, and have swarmed naturally. In the instances in which worker-comb of *Apis mellifica* was supplied, it was used for raising drones, and so these stocks yielded scarcely any surplus. It does not resist the ravages of the moth. Both these bees are incapable of crossing with *Apis mellifica*.

Apis dorsata (normally building under boughs, but frequently in caves) is the giant of the genus *Apis*, the smallest of its workers being quite equal in size to the largest of the queens of any of the European races. There are several varieties of this bee scattered over India, Sumatra, and Java, the larger being found in the hills. The thorax is black beneath, with reddish hairs; the upper part yellowish,

* "Hive Bees Indigenous to India," by J. C. Douglas.

with brown, triangular spots; but the colours are darker in the hill varieties than in those inhabitating the plains. The comb has 4½ cells to the inch, and no drone-comb, as distinct from worker, is constructed; and, as might be supposed from this, the drone is the same size and shape as the worker, excepting that it has the eyes meeting above, as in the drone of *Apis mellifica*. The question of crossing with *Apis dorsata* has already received notice (page 315). All attempts at permanently hiving it have to the present been abortive. In many parts it migrates regularly at certain seasons, its habit being to leave its comb on failure of pasturage, reminding us of the "vagabond" swarms (page 168) of *Apis mellifica*.

Apis florea is interesting as being the smallest known species of the genus, while its drone is, relatively to the worker, the largest, and most differentiated from the female and worker. Its worker-comb, of nine cells to the inch, is beautifully regular. The drone-cells are thick on the sides, six to the inch, and circular in cross-section, adding, if it were needed, confirmation to the theory that the hexagonal form of the bee cell is due, not to design on the part of the bee, but to crowding together of cells which, if separately constructed, would be cylindrical.

Several other varieties are known to naturalists; but, as these generally give no promise of being, under any circumstances, reducible to domestication, they are of little interest to practical apiarians, and so are here left out of view.

Beyond the confines of our Indian empire bees exist, but the accounts given by travellers, through

pardonable ignorance, are so confused and indefinite that it is difficult to trace distinctions.

Dr. A. Gerstäcker concludes that the Egyptian variety* extends over Syria and Arabia, through imperceptibly minute variations in the Himalayas, on to China. Central Asia appears to be deficient in hive bees, although they are found in Siberia and Trans-Caucasia. R. P. David refers to Chinese bees, of which the swarms are placed in hives formed of the hollowed trunks of trees; but Trschewalsky did not find them in any of the Chinese provinces visited by him. Apiculture is not unknown in Japan, but of the races of bees cultivated our information is very scanty. Hives are described as made of plank, with flight-holes below, and arranged in stands with a projecting platform. Swarms are frequently caught in straw hives suspended near to nests of wild bees, and in which sugar has been placed. A swarm having taken possession, it is brought to the hive in the garden of the house.

Hive bees—and, amongst them, notably the best-known species, *Apis mellifica*—as friends and companions of man, are spreading almost wherever civilisation reaches, for bees, aided by man's attention and care, can exist under conditions which would entirely prevent the settlement of the insect in the wild state. The domestic bee is, therefore, not only able to maintain itself, but is actually profitable in the most diverse, and often in very unfavourable, climates. It is found in the far north in Europe, sounding its cheerful hum in Lapland, while it flourishes on the sunny slopes

* Dr. Gerstäcker regards *fasciata* as a variety of *mellifica*.

of Africa, existing in great abundance in Algeria, where it is domesticated by the natives, vastly helping the hill races, who deal in honey, but, above all, in wax. It has also multiplied enormously in both North and South America, in the latter tending to displace the *Meliponæ* and *Trigonæ*, which, although belonging to the *Apidæ*, are generally inferior to the genus *Apis*. The many species of *Melipona* are short, squat, little bees, with very varied colours, and but few pubescent hairs. Their legs are small, and they are quite incapable of stinging, although the rudiments of the organ of offence is discoverable. Their combs are horizontal, supported on columns, with the single tier of cells mouth downwards. In these the eggs are laid, and the larvæ fed, but they store their honey and pollen in huge, irregular cells of wax, placed near to the brood-nest. Their usual habitat is a hollow tree, but they are not slow to occupy a box or basket. *A. mellifica* domesticated in Chili keeps its hive filled with honey all the year, needing no care. By its introduction to Australia, it has not only multiplied, furnishing rich harvests, but has, as in America, returned to the wild state, multitudes of swarms living in hollow trees, out of the reach of man, side by side with the native *Trigona*. New Zealand has its fauna enriched by it; it is flourishing in New Caledonia, and holds its own as far South as Auckland Isle. It has made its home in the West Indies, and gathers its honey in most of the islands of the South Pacific and South Atlantic oceans. It is a pleasant reflection that the little cosmopolitan is one of the beautifiers of the earth, increasing floral loveliness and multiplying fruit.

CHAPTER XIV.

CALENDAR.

THE arrangement of a Calendar is necessarily somewhat empirical. The work of one season glides imperceptibly into that of another; while, in a climate and country such as ours, due allowance must be made for seasonal fluctuations and differences in latitude. It is therefore recommended that, when a reference is made, the months before and after the current one receive some attention; while the index should also be consulted. My readers will, without doubt, subscribe to a bee periodical, in which advice suited to passing conditions is invariably given; brief notes, therefore, are here sufficient.

JANUARY.

This is the season of rest in the apiary. Do not needlessly disturb any colony.

Food.—If neglected stocks have been purchased, or an oversight has been made, and any are suspected to be deficient in store, give candy (page 396), or even confectioners' barley sugar. Cover the food given warmly, under the quilt or chaff-tray, or with skeps

put it into the feed-hole, carefully closing every opening, to prevent any leak of heated air. Semi-starved bees, huddled together, cannot move to take food in the face of cold; such must be carried to a warm room, and kept in the dark, until they have fed up.

Snow having fallen, consult page 533.

Entrances may be examined the first fine day after a cold spell (page 532).

Insectivorous Birds, if troublesome, should be kept from the alighting-board by wire net (page 578).

Hives lying empty should now be made ready for the future season; clean, repair, and improve. These, if sound and of good pattern, when thoroughly overhauled and repainted are better than new, as their joints are not likely to open in the sun. Stand legs in saucers of crude carbolic acid; this will be absorbed, and rotting be effectually prevented (page 119).

Section-crates may be prepared, the section-boxes containing worked combs arranged, and in others, even thus early, the foundation may be fixed; although the wax will harden slightly, the warmth of the hive will soon render it plastic.

Make all possible preparation for the busier time, which will bring with it more than sufficient employment.

February.

All the hints for last month (which *see*) still apply, especially those referring to the needs of the bees.

Food.—If the weather be so warm as to induce the

bees to fly often, much more food will be consumed than if they remain in cluster. On a warm day, the needy may have a stored comb (not given icy cold) exchanged for an empty one, or thick syrup may be fed to them; but candy is to be preferred.

Move Bees, that need moving, after a cold spell (page 426).

March.

Bees, stimulated by their more frequent opportunities of leaving their hives, and by the welcome, though small, supplies given by opening snowdrops and crocuses, followed by almond and peach trees, elms, willows, &c., begin now to carry forward the work of raising brood in earnest. Make a cautious examination (page 410), and, if essential, feed. In the South of England, if dependent upon orchard honey (which is not first quality), stimulate at the same time, crowding the bees on to a few combs.

Borage may be sown along the hedgerows.

The Sunflower, sown now, although helpful in autumn, by providing pollen, supplies, unfortunately, a soft, resinous body, which the bees use as propolis, making their hives most disagreeable to the manipulator.

Queen Wasps now begin to make their appearance, hovering about the hives. They should be diligently destroyed (page 579).

Hives towards the end of the month may be exchanged for the newly-painted ones, while the removed may be still put into trim for increase in stocks.

April.

The bee-keeper's season is now open ; his favourites are increasing in numbers and activity. Some of the orchard trees, at the close of last month, and early part of this, in forward seasons, are in full spring attire, and, in favourable weather, the stocks are gaining weight. Yet at this time, perhaps, more colonies are ruined through want of food than any other. The winter has disposed of the honey of the previous year, and brood-raising now requires a good income to meet necessary expenditure;

Feeding is, therefore, essential in prolonged unfavourable weather; if this should be forgotten, the bee-keeper will probably meet with

Signs of Starvation, in the form of the bodies of immature bees (white bees), on the alighting-board. Food failing, ovipositing has been stopped, the eggs and younger larvæ eaten (page 248), and the chrysalides (especially of drones) torn from the cells and thrown out of the hive. Feeding immediately will save the stock, but not until it has been so checked that it is unlikely to yield much surplus.

Artificial Pollen may be given (page 399).

Spread Brood with caution (page 414).

Water must not now be overlooked (page 404).

Transferring may be undertaken (page 242).

Queenlessness may be suspected if, while colonies generally are carrying high-standing pellets of pollen, the one under examination takes but a small number of half-sized ones. Should no queen exist, the best policy is to unite to a weak stock having a queen (see "Uniting").

Queen-raising and drone-raising stocks should now be selected, and receive the best attention.

Robbing is likely to occur. Carefully avoid spilling syrup, and keep no hives open longer than necessary.

Foundation may now be built into comb, and, as an aid in this work, dry-sugar feeders are excellent.

May.

Good colonies are now becoming crowded, and care must be taken to give room as needed, while the queens should be encouraged in breeding to their utmost.

Feeding will be required in a wet, cold May, while in a fine, warm one,

Sections must be provided.

Swarms, if purchased, should, if possible, be secured this month.

Nuclei may be started (page 294), and

Queen-cells, from selected queens, should now be obtained (page 228 *et seq.*).

Phacelia, Melilot, Clover, &c., may be sown; ground otherwise idle may thus be occupied to advantage.

June.

Special vigilance must be exercised to prevent the swarming of the honey stocks, extracting or adding crates of sections or empty combs as may be required.

Swarms issuing from hives, carrying partially-worked sections, may be treated as explained at pages 165 and 511, receiving the sections left on the stocks, when the former will be continued with no perceptible check.

Swarming for increase may be continued through the month.

Feeding swarms issuing at the beginning of protracted bad weather is very important.

Extract the fruit honey separately from that from white clover, which is in full yield at the latter part of this month.

July.

This is commonly the busiest season, yielding the greatest weight of honey, as wild flowers abound, and the clovers are followed immediately by lime.

Gluts of Honey will occasionally force the bees to fill up the brood-nest with store; in this case they hang idle in front of the hive, as before swarming. In giving additional room, provide as much clean comb as possible (pages 494 and 502).

Shade is desirable, lest combs melt, and fall from their attachments; but light-coloured, wooden hives, with ample entrance, or propped up from the floor-board, can hardly, thus far, suffer in the most ardent rays of the sun.

Section-crates may now be removed as fast as fully sealed.

August.

Those who are near to heather have yet another harvest for their bees, as the moors now assume their purple tone. Frame hives and skeps travel best to the moors as explained at page 429.

Drones are usually now worried out of the hives. If any colony suffer its drones to live when they have

been driven out generally, that colony is probably queenless.

Wasp Nests should now be searched out and destroyed before the new generation of queens scatter abroad to hybernate.

Robbing is again likely to occur, therefore contract the entrances of the hives somewhat.

Surplus should now be removed, early in the morning or about sunset, and honey must be exposed as little as possible, or temptation will work mischief (page 500).

September.

The harvest, except in heather districts, is over, and the aim should now be to gradually get the bees into a restful condition, in anticipation of wintering.

Light Skeps, as pasturage is now scanty, may be purchased very cheaply of cottagers, for transferring. These, if in fair order, may, by feeding, be made into good stocks.

Condemned Bees may be bought, and treated as explained at page 368. Whilst drumming bees for yourself, show to the owners the method, and point out the folly of destroying the little labourers in the sulphur pit. You may not be able to make bee-masters of cottagers in one lesson, but you can let in some light, and may be gratefully thanked for your kindness; while your willingness to buy that which the old system destroys, is an unanswerable argument that there is waste somewhere.

Queens of special race may be purely mated by drones from queenless stocks (page 322).

Drones may be preserved till the end of the next month in any stocks, queenless or not, by constant feeding.

Feed up to wintering weight, getting the operation completed by the end of the month.

Pollen may be transferred, in a frame carrying abundance, from any stock to your condemned bees, the latter giving in exchange one of their newly-built white combs; both stocks will thus be gainers.

Unite weak colonies and nuclei, if not done previously.

OCTOBER.

Stocks now return from the moors, and honey for the year is over.

Wintering Preparations must now be made. Condense the bees, and increase the interspaces of the combs. Consult "Wintering."

Hives, if leaky in the roof, or in any other way in need of attention, should have their contents transferred to sound ones, for the benefit of the stock and the repair of the hives.

Shelter the hives in front, in anticipation of snow (page 533), so that the bees may not be bewildered about their entrance by new arrangements in colder weather.

Condemned Bees, in the first or second week of the month, if strong in numbers, may still be fed into good stocks, especially if helped by one or two pollen-bound combs.

Honey and comb must receive attention, the latter, if free of moth trail (page 576), being carefully packed, or hung up until required in the spring.

Wax scraps should now be run down into block, as explained at page 589 *et seq.*

NOVEMBER.

The bees have now retired into winter quarters, and, aided by a thoughtful and skilful master, they, shoulder to shoulder, will keep the cold at bay, while they moisten their candy or sip their honey beneath their chaff dome, requiring only nominal attention, as they wait the return of the sun to once more warm the earth, and bring into being a new carpet of flowers.

DECEMBER.

The bee-keeper has himself retired into winter quarters; if he be wise, not only to wait, but to reflect, plan, and prepare, so that the studies and observations of the past may be the seed-corn of a greater harvest of success in seasons yet to come. If the preceding pages should aid in securing so desirable a result, the object of the Author will be so far attained: but he would feel, with the reader, that each step taken is mainly to be valued because it enables us to make another advance; for the hope of progress should be the charm of every effort, in little as in greater things, transforming the dead routine of mere existence into the elasticity of abounding life. He would therefore say:—

Let us, then, be up and doing,
With a heart for any fate;
Still achieving, still pursuing,
Learn to labour and to wait.

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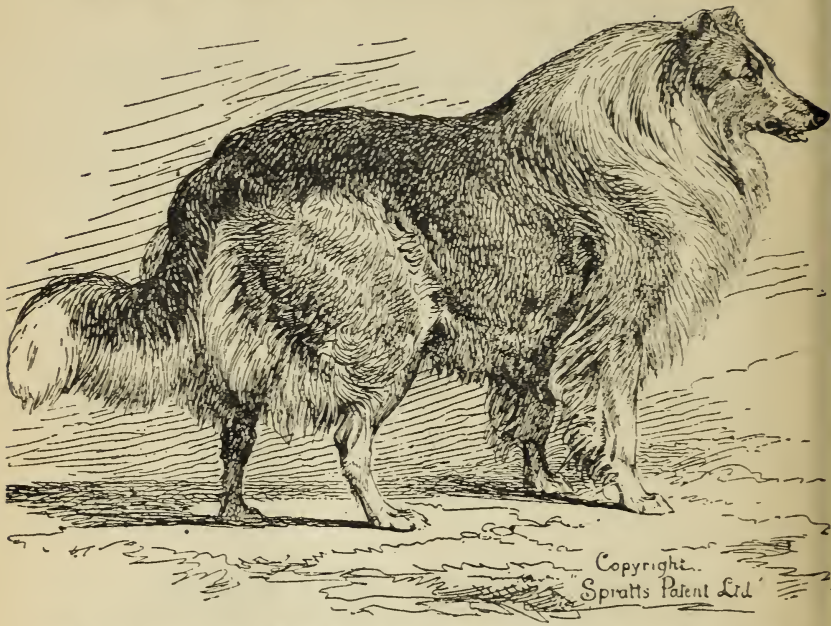

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